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SUPPLEMENT

TO THE

PROCEEDINGS

OF THE

SECOND ANNUAL CONFERENCE

Asociación de Técnicos Azucareros de Cuba

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BY-PRODUCTS OF THE CANE SUGAR INDUSTRY

Opening speech at the Second Conference of Sugar Technologists, made by Mr.
FERNANDO GUERRERO,
President of the Association of Sugar Technologists of Cuba.

This Association of Technologists of the Sugar Industry, in the name whereof I address you at the opening of our Second Annual Conference, is, as is known, composed of those who devote all of their activities to the study of the problems connected with our national industry.

Our Association was formed two years ago, shortly prior to the meeting at Havana of the Second International Conference of Sugar Technologists. The by-law and objects of our Association are the same as those of the Associations of Sugar Technologists of Hawaii, the Philippines and Java.

It should be stated that the principal base for the foundation of this Association was the decided cooperation of the Directors of the Cuba Sugar Club, whose enthusiasm and high aims are shown by their organization to improve our national industry.

At this Conference, which will continue for three days, many interesting papers will be read by their respective authors and submitted for discussion; from an industrial as well as an agricultural standpoint there will be a number of particularly valuable reports on new varieties of cane and its propagation in Cuba, others dealing with the cheapening of transportation of the raw material, and many relative to improvements in boiling-house methods.

Our Association is deeply appreciative of the cooperation which it is receiving from the Engineers Association, which has loaned us its building for our meetings; as also of the moral and material support which has been given it by the Cuba Sugar Club since its foundation, and it wishes to express its thanks to both of these organizations.

But what gives us the greatest feeling of pride, enthuses us, and animates us in our work, is to note how, for some years past, technical problems have had the marked and complete attention of the Honorable General Gerardo Machado and of his cultured Cabinet who, once again giving their support to these matters of National interest, have this day honored us with their presence at this inaugural act. In these years of industrial crisis, our governing elements, legislating with extraordinary skill, have shown themselves to be fully cognizant of technical problems, since all improvements, studies or merely ideas of this character have always been given their immediate consideration.

It is not yet three weeks since the President of the Senate, in an interesting

discourse, outlined considerations of great importance with respect to the necessity of utilizing the by-products of the sugar industry, and at the last session of the Rotary Club Dr. Vázquez Bello, with a profound understanding of the problem, again discussed the utilization of molasses; I, thoroughly agreeing with him in some of his statements, wish, as a technologist, in a few words, to summarize the methods and point out what may be expected from the by-products of the cane sugar industry, and how, by making the utilization of these by-products practicaly possible, we technologists can collaborate to eliminate the crisis through which our first national industry is now passing.

Everyone is aware that the utilization of by-products has made it possible for many industries to subsist to-day, which, without them, could not have placed their principal product on the market at an attractive price; I am referring to various chemical industries which I shall not cite at this time, as my only intention at present is to compare the cane industry with two agricultural industries: "the cotton industry" and "the corn industry."

I believe that if the energy of the planter and the fertility of the soil are expended equally in obtaining the principal product and the by-products, it is not good policy, either economically or industrially, to confine onesself to the manufacture of the former while abandoning the latter.

Less than fifty years ago the cotton plant was cultivated solely for the fiber which it yielded; only forty years ago the health authorities of the United States issued regulations with respect to the method of disposing of the residues of that industry, composed of seeds and hulls which were only used in part as fuel; even at that time the difficulties arising from those residues, had caused the bankruptcy of more than one manufacturer. But competition, cotton fiber produced in tropical countries with extremely low labor costs, compelled technologists and manufacturers to seek a means of reducing the costs involved in getting rid of those residues and to endeavor to obtain something therefrom which would at least assist in covering those costs. Thus, gentlemen, was initiated the industry of cotton by-products. Let us see how it has grown:

The value of the entire output of by-products of the cotton industry in the United States in the year 1926 was $256,027,431. As the value of the cotton crop itself in that year amounted to $982,736,000, we find that to-day those by-products represent, for the planter and manufacturer, more than 25% of the value of the principal product. These figures were obtained from the Department of Agriculture at Washington, from the latest complete statistics on that industry.

I shall specify in a few words the principal by-products; of the total thereof

52 ½% represents oils of all kinds, from that for domestic use to that employed in the manufacture of soap.

34 ½% cakes employed in part as food for cattle and as nitrogenous fertilizer.

6 % residue of the fiber, employed in the rayon, cellulose and pyroxylin industries.

7 % hulls: from these are now obtained "furfurol," acetone, acetic acid and fertilizers.

That amount of products, valued each year at more than out sugar crop, would still be lost were it not for the technologists.

Some years ago I had occasion to study the corn industry in the United States, and at that time some 26 by-products of corn were on the American market. It would be venturesome now to fix an exact number of the by-products of that in-

dustry, as it would be also to state what is a main product and what a by-product of this grain, since some new derivative is appearing on the market daily or acquiring greater importance.

The corn technologists state that if for each 100 pounds of grain produced, there are produced 150 or 200 pounds of leaves, roots and cobs, it is as logical to endeavor to utilize the cobs as the grain. And in fact they have succeeded in obtaining from the cobs and from the stalks of corn, among others, an important product—"furfurol": this is a liquid obtained by distillation under specified conditions of any material containing "pentosanes," and is being employed at present in large quantities as a dissolvent, in the manufacture of lacquer and varnish. Eight years ago it was a laboratory product costing $30 per pound; at present some 700,000 pounds are manufactured annually in the United States, at a price of 12 to 14 cents a pound. Another product which has already been extracted from corn cobs, and is now beginning to be utilized in industry, is "lignin"; a dissolvent has already been discovered, which will permit it to be used in the manufacture of certain varnishes.

From the latest complete statistics of the Department of Agriculture at Washington we take the following data with reference to the principal products of corn, manufactured in the year 1925. Corn starch, 854,125,000 pounds, having a value of $33,716,000. Corn syrup, 1,144,858,000 pounds, having a value of $41,275,000. Corn sugar (glucose) 580,370,000 pounds, valued at $19,505,000; and corn oil, 12,705,000 gallons, with a value of $14,093,000. A great part of this corn oil is so well refined that it is employed for domestic consumption.

With reference to glucose, which is a serious competitor of ours in the preserving industry, and which is already being produced in part in crystallized form, we take the most recent data, as follows:

In 1919 the production was only 157,276,442 pounds, valued at $9,314,977, the production in the past year having reached 896,738,765 pounds, with a value of more than $30,000,000.

It is certain that this year the production will pass 450,000 short tons, without counting corn syrup, the production of which is usually twice as great.

This will give an idea of what the corn technologists have done in the last ten years, and there is no doubt that their work has affected our industry.

Let us see now what the cane technologists have done and are doing to utilize its by-products, and after having seen that corn can commercially sustain the production of products so varied as oil and "furfurol," we shall not consider as a dreamer the technologist who suggests to us the products which the sugar mills will some day obtain from cane.

Up to the present the only material considered to be a by-product and from which our manufacturers obtain a profit is molasses. If we consider the production of molasses for five years and the price at which it was sold, we shall see that the selling price of all molasses does not reach $8,000,000 per crop; in consequence our by-products represent only 3% of the value of sugar produced.

The bagasse which we use as a fuel has a value which can be figured on the basis of what it would cost to replace it by petroleum or pulverized coal. On this basis, substituting it by some other more appropriate fuel, we find that the value of a ton of wet bagasse does not reach $2; let us see what can be obtained in dollars and cents from a ton of bagasse, manufacturing or extracting from it other products of greater value.

In discussing the derivatives of bagasse, let us begin with celotex.

Only seven years ago the manufacture of celotex was in an experimental stage, and at present the celotex plant is manufacturing daily some 1,200,000 square feet of this product. The production of celotex in the past year was 300,000,000 square feet, and in its manufacture there were utilized some 250,000 tons of bagasse from 35 Louisiana sugar mills. In order that we may better realize what this figure means, we may state that with the celotex manufactured this year it would be possible to construct a fence four feet in height entirely around the United States.

The value of this product at the factory was some $9,000,000!! In other words, it was worth more than the whole Louisiana refined sugar output in the past year, which did not reach $7,000,000.

As the demand for this product is increasing and sanitary regulations prevent the importation of bagasse into the United States, to the success of this industry is due primarily the resurgence of the cultivation of cane in that country. A subsidiary of the celotex company is developing a large sugar mill in Florida. The Louisiana sugar cane crop this year will be double what it was in the year 1927.

The product is a porous board, with insulating properties, which is used for interior walls of houses, in concert halls, in the construction of refrigerators, etc., etc.

Not only is celotex used in the United States, but is now exported from there to all the countries of the world.

The process of manufacture is simple: the bagasse received at the factory, in bales, is placed in "digesters," to transform and dissolve all the soluble materials or those susceptible of fermentation; later it is passed through a beater for the purpose of preparing the fiber, after which it is again washed and certain chemical products are added to it before it goes to the molding presses and drying ovens from which it comes out in panels of different sizes. Practically the entire process is automatic, and a bale of bagasse only requires six hours to be converted into sheets or panels of celotex.

One ton of wet bagasse, which we have estimated to be worth less than $2, produces from $30 to $40 worth of insulating board. This labor of American manufacturers and technologists is very praiseworthy and should be imitated, as it has resulted in making sugar, which was formerly the principal product and object of the industry, into a by-product.

Cellulose and paper. The first attempts to obtain paper from bagasse were made as far back as 1838, since on that date and again in 1856 there were registered two English patents to this end.

In 1870 more serious experiments were made in the French West Indies, with this object in view. Texas had its first experimental plant in 1900.

But the first factory of commercial capacity was apparently built on the Island of Trinidad in the year 1910; this plant had a capacity of ten tons of paper daily, and produced a good grade of wrapping paper, composed of 65% bagasse, 20% bamboo and 15% "Parana grass." During that same year another factory, to produce paper from bagasse without the use of other materials, was installed at Caconda, near Rio de Janeiro, and according to reports, there were obtained around three tons daily of ordinary paper, produced by treatment of ten tons of bagasse. In Cuba also, at Central Preston, important experiments were made in 1916, with the intention of developing this industry.

All of these efforts, although good paper was produced, proved to be failures commercially.

It is also curious to note that nearly all the patents relative to obtaining paper from leaves and stalks of corn are made extensive by their inventors to cover the same processes in connection with bagasse; and there are many of these patents.

If we make a complete analysis of dry bagasse, we shall find that in addition to sugar, it contains:

From 35 to 40% of cellulose
From 20 to 25% of "pentosanes"
From 12 to 16% of "lignin"
And from 2 to 3% of ashes.

The possibility of extracting at least 30% of the weight of bagasse in cellulose is beyond question. And as, by reason of the increasing demand for the derivatives of cellulose for the manufacture of artificial silk, the enamel industry and lacquers based on pyroxylin, the value of this product has increased considerably, chemists are seeking new methods of separating the cellulose from the bagasse, dissolving or eliminating in any way possible the other substances which are associated with the cellulose in the bagasse.

Utilizing a newly patented procedure of Mr. Joaquín la Rosa, there has been installed at Central Tuinucú a large cellulose plant having a productive capacity of 40 tons per day.

The Cuban Cellulose Company, according to announcement, has succeeded in obtaining a product in condition to reach the market for utilization by paper factories or other industries which require cellulose as raw material.

We are indebted to the inventor, Mr. la Rosa, for a series of samples of paper of all kinds which are on exhibition at the office of the Secretary of this Association, for examination by our members.

From the description which Mr. la Rosa sent us we can state that the process consists in treating the bagasse in "digesters" under high pressure, and that the purification is effected through the use of chlorine, sulphur and lime; it being noted that the cost of the chemical products employed is less than the cost of those consumed in the manufacture of wood pulp.

Another process for the extraction of cellulose from bagasse, utilizing the patents of Mr. Hemmer Valette, is being tried out at Central Cuba.

Synthetic planks or lumber from bagasse. The Vazcane Corporation is a new company formed to operate under the patents of Engineer Antonio Vázquez, one of our members.

The Vázquez process for manufacturing insulating board or synthetic lumber, is entirely different from those invented up to the present. In order to better utilize the entirety of the cane fiber, he introduces a new system of extracting the juice; this process changes the system of grinding cane with tandem mills of three rolls, into a system of defibering the cane without destroying a certain condition of its fibers, and for this purpose he uses mills similar to those used in the manufacture of paper pulp.

The cane pulp produced by these mills is passed to a continuous diffusion and defecation system, although as a matter of fact it would be sufficient to pass it through an ordinary diffusion battery, but the Vázquez diffusion system is so ingenious that it permits the separation of perfectly washed pulp, and of perfectly clear juice filtered through the pulp itself. The juice, which, according to the inventor, will not contain

a greater amount of water than is contained in the juice of a modern sugar mill, is manufactured into sugar by the usual methods. The washed pulp, containing all the insoluble elements, passes to the "beaters," which are apparatus to equal the fiber. From these it is pumped to a machine similar to that employed in the manufacture of cardboard. A cutter separates and delivers sheets of this cardboard to drying presses which turn out the product in sheets of the desired size. The kind of material manufactured and the thickness thereof depends on the form of operating the apparatus used for handling the pulp.

By this process insulating board is manufactured that may be devoted to the same uses as celotex, or synthetic lumber may be produced which is as hard as the best wood.

The plant which the Vazcane Corporation is constructing at Marianao will be ready within a month, to grind the crop which we are about to begin; its capacity is 100 tons daily, producing from 10 to 12 tons of board a day; that is to say, there will be produced daily some 30,000 square feet of insulating board of ½ inch in thickness, or equal amount of synthetic lumber with a thickness of ¼ inch. This factory will also obtain some 12 tons of sugar daily.

A particularly interesting feature of this new installation is the new mills, two in number; arranged to work in parallel, each has a single roll, horizontal, which is a "carborundum" stone of 20″ diameter by 42″ in length, mounted on a steel shaft and having a velocity of 1200 RPM, with a consequent perispheric velocity of 5,000 feet per minute.

The cane is elevated by the usual carriers and deposited in hoppers which have a height of approximately 20 feet by the length and width of each mill; this pile of cane is caused to fall vertically on the upper surface of the stone while it is revolving at high speed. The lower half of the rolls work covered with water, and the pulp, caught in a tank situated beneath the mills, is pumped from there to the diffusion apparatus.

The power plant consists of a boiler having a capacity of 12,000 pounds of steam per hour, to work at a pressure of 450 pounds per square inch; this high pressure has been considered to better effect the thermal balance of the plant. The consumption of fuel oil has been estimated at 2,400 gallons in 24 hours.

Alcohol from bagasse. For more than one hundred years it has been known that it is possible to obtain ethyl alcohol from any vegetable fiber, including sawdust; the most notable of the processes to obtain ethyl alcohol from sawdust is that of Claassens, and was used commercially in Germany during the last war; by this process some 12 liters of alcorol were obtained for each 100 kilograms of dry sawdust.

Some distinguished chemists have suggested, in view of the great similarity between the chemical composition of bagasse and that of sawdust, the possibility of obtaining alcohol from bagasse, noting that, from the elements contained in the bagasse, a more satisfactory yield of alcohol should be expected than is obtained from sawdust.

It is not a question merely of fermenting the sugar remaining in the bagasse; the cellulose which the latter contains can be transformed into starch by known processes, and then into fermentable sugar, and the "pentosanes" which are also contained in the bagasse can also transformed into fermentable sugar by means of a new bacteria recently discovered: these two sugars, together with the sucrose and the glucose contained in the bagasse would be utilized in the alcoholic fermentation.

This very new process has not yet been tried out on a sufficient scale to make any calculation as to its economic possibilities. But on a purely theoretical basis I find that it would be possible to secure a yield of 150 liters of alcohol per ton of bagasse.

Other derivatives of bagasse. The processes used to extract "furfurol" and "lignin" from corn-cobs, would be applicable to bagasse, which is as rich as the former in those component materials.

The time is not far distant, also, when it will be possible to transform the constituent materials of bagasse into others of a more digestible nature, for use in the preparation of cattle food.

"Filter Presses Cakes" and trash from the cane. Some of the proceedings indicated for utilization of bagasse may be extended to "the filter presses cakes and cane trash.

Certain canes, particularly the Uba variety, produce "filter press cake" containing from 14 to 17% of vegetable wax. A sugar mill of Natal (South Africa) some years ago installed a plant for the extraction of wax from "Filter Presses Cakes", employing benzol as a dissolvent.

In the small sugar zone of Spain the "filter press cake," which they call "salvadillo" is used in the preparation of cattle food.

Molasses. The annual production of molasses in Cuba fluctuates between 220 and 250 million gallons; considering the average price of molasses in recent years, we have previously stated that the revenues of the industry, for that item, scarcely amount to $8,000,000 per crop. We all know that fortunately our molasses for some months past has been quoted somewhat higher, but we should not overlook the quotations on this product some years ago.

As I have previously stated, Dr. Vázquez Bello has dealt with this subject with perfect understanding; there is little to add to what he has stated, but I would like to furnish some statistical data.

The importation of sugar-cane molasses into the United States in the year 1927 amounted to 275,747,000 gallons, 80% of which was from Cuba. There were used in that country in the past year, in the manufacture of alcohol and its derivatives 233,179,066 gallons, from which some 90,000,000 gallons of alcohol of various kinds were produced, the total value thereof being more than $35,000,000, while the derivatives were worth as much more.

This gives an idea of the important industry of which our molasses is the basis and raw material. The production of alcohol in the United States in the previous year was even greater.

The balance of the molasses imported was consumed by other industries, also of importance, among them being that of compressed yeast and that used for food.

Having indicated the value of the derivatives of our molasses, it is unnecessary in this report to give a detailed description of each industry, or to indicate in detail the applications of alcohol: we shall limit ourselves, therefore, to mentioning as the most important products of molasses and derivatives of alcohol: yeast, lactic and acetic acids, sulphuric ether and ethyl lactates and acetates. Among these latter I may state that in the past year there were manufactured in the United States 50,273,000 pounds of ethyl acetate, having a value of $5,000,000; the manufacturers of lacquer and enamel on the basis of pyroxylin, who are also consumers

of many other solvents exclusively derived from alcohol, are the great users of this product.

The newest process for manufacture of ethyl acetate, utilizes alcohol exclusively for that purpose.

In short, as by-products of distilleries we have potassic salts, superiors alcohols, and the ethers thereof; carbonic acid, from which the new dry-ice industry has sprung; this is no more than solidified carbonic acid, the consumption of dry-ice in the United States being enormous. Carbonic acid is also employed in many chemical industries.

Another by-product which the largest distillery in the United States is now beginning to put out is glycerine, obtained from distillery residue. At the present time the United States imports glycerine; possibly through the development of this process it will cease to be an importer, and will become an exporter.

The obtaining of glycerine from materials containing sugar is not new; what I am referring to is a new process for extracting the glycerine existing in distillery residues; by this process one gallon of molasses, in addition to alcohol and other products, will render about one pound of glycerine, which latter at present costs only twelve cents.

In Cuba, apart from the molasses utilized by a plant for the preparation of cattle food and the molasses consumed by the new compressed yeast factory of the Fleischmann Company, there were employed in the past year only some 20,000,000 gallons in the 32 distilleries operating in the Republic, but it should be noted that these distilleries have a total capacity of two or three times that much molasses.

We should note that 50% of this molasses was used to produce, not alcohol, but brandy or rum, and special conditions of fermentation are required to obtain the aroma in these products; this is why some foreign technologists, judging the matter superficially, have lately stated that this industry in Cuba is in a backward state. The distilleries of Cuba have for twenty years utilized methods of fermentation by means of pure yeast culture, and there are in Cuba a number of distilleries which are models of modern installations, having complete equipment for the utilization of the principal by-products.

If the distilling business in Cuba has not been a prosperous one, it has not been due to lack of ability of the manufacturers and technologists. There must be other reasons.

In short we should consider sugar cane to be the source of raw material for many industries, and from the foregoing it will be seen that it is not very venturesome to look forward to obtaining from this plant products having a value equal to that of the sugar, but to this end the technologists and the laboratories are necessary.

Every measure which tends to the development in Cuba of the industries of bagasse or molasses, and every measure which facilitates the work of the technologists or the creation of research laboratories, is an important step toward the cheapening of sugar.

The Cuba Sugar Club established some years ago and has under operation at Baraguá a model agricultural laboratory.

On behalf of the agricultural technologists who teach us how to obtain more cane and more sugar per hectare, and of the industrial technologists who show us how to extract all of the products, I wish to express the hope that we shall continue

to receive from manufacturers and from the Government the support which we have been receiving, considering us a factor of importance in the problems of an economic nature. Evidence of our collaborative force is this Second Conference which we are now inaugurating.

THE NEXT SPEAKER WAS MR. JUAN G. SALINAS, WHO DEALT WITH THE PROBLEMS OF IRRIGATION OF CANE AND THE SYSTEM OF CONTRACTING FOR IT, IN THE FOLLOWING ELOQUENT MANNER:

When Alvaro Reynoso affirmed, and proved beyond a doubt in the very cane fields of Cuba, that "Sugar Cane is a Plant requiring irrigation," he laid down an agricultural maxim of immense importance for the economic future of Cuba. Many decades have elapsed since that statement was made and sustained by that super-agriculturalist, without it having been, so far, taken at its true value among us and placed in practice on a commercial scale. The idea and the complementary system of cane planting eulogized, the genesis of which, although it may appear paradoxical, is genuinely Cuban, have nevertheless been intelligently and fortunately applied by planters of cane of other countries, and with respect to the results obtained there is no better argument than figures for production per acre, in which we are inevitably placed in a very poor light in this matter of cane growing. These figures give the first two places to Java and to Hawaii, which have followed, as their agricultural catechism in the practical cultivation of cane, the recommendations of Reynoso, with an average production per crop of FOUR TIMES that obtained in Cuba, because of the fact that up to the present our country has followed an agricultural routine, the reasons for which we shall not analyze, but for the results of which we have been and will continue to pay dearly.

Java and Hawaii at the present time produce, on lands under irrigation, an average of 6.5 to 7.0 long tons of sugar per acre (equivalent to approximately 20,000 arrobas of sugar per cab), while Cuba, with lands very much more fertile than those of the two countries cited, only produces, taking as a basis the figures of the last crop, from 1.8 to 2.0 long tons of sugar per acre (equivalent to approximately 5,600 arrobas of sugar per cab). That difference of 14,400 arrobas of sugar per cab (equivalent to approximately 1,100 sacks of sugar) is really extraordinary, and should, therefore, be made the motto of the Directors of the Sugar Industry in Cuba, as a synthetic program, the development of which requires no more than the rooted conviction of its necessity and of the assured advantages which would result to industry and to the country, and thereafter, a firm will to place it in practice.

The sugar industry of Cuba is of such enormous magnitude, comparatively, and on the other hand the factors involved are so varied and complex, that in truth it resist the same treatment which has been placed in force in other countries for its more or less fortunate control and management.

Like any industrial activity on a large scale, its natural evolution must lead it to practice all the improvements made possible to it to-day by Science, as well in its varied agricultural aspects, as in transportation, as in industrial engineering, and finally, in the important aspect of its manufacture.

As regards its commercial aspect, in connection with the price which sugar

reaches or may reach in the consuming market, we firmly believe that this will only begin to be controlled with real probabilities of success when the sugar industry is definitely established here on scientific bases of production. So long as this object is not accomplished, in which object this Association of Sugar Technologists is disposed and anxious to cooperate, the business of producing raw sugar, or sugar of 96° polarization will continue to be one of the numerous speculative businesses in which, because of circumstances of irrefutable industrial logic, the producer of raw sugar in Cuba will continue to occupy the weakest position, and the National economy to suffer the inevitable consequences of that present unfavorable position.

For all those reasons, it is incumbent to consider with the greatest interest the application of all the technical advances and the adaptation to the psychological, agricultural and industrial condicions of our country, of all those forward steps of a scientific character which in other sugar-producing countries and in our own, having been accomplished by the efforts of Sugar Technologists consecrated to the useful practice of planting of cane and operation of sugar mills, have already been definitely approved by experience.

In this function of genuine National Defense the Association of Sugar Technologists of Cuba is sincerely and enthusiastically engaged, the first steps having been taken for the benefit of the Cuban sugar industry long before its official formation in 1927, by reason of the Second Convention of the Internacional Association of Sugar Technologists, which took place in this city of Havana in the month of March of the past year.

This parent organization of Sugar Technologists, of a private international character, may take credit for our constitution into an association, uniting in its membership all the Sugar Technologists who consecrate their activities in Cuba to the tasks of the sugar industry, without taking into consideration in any way nationalities or academic degrees, which are not precisely requisites for collaborating in a useful and effective manner in this common effort to improve the sugar industry of Cuba. And this Association, which since its inception has been looked upon with favor by the Government, with which it is pleased to cooperate in the study and solution of the problems of a technical character in connection with the sugar industry, owes its success principally, and we, its members, are pleased to so declare, to the Cuba Sugar Club, a cooperative organization of mill owners and sugar companies which has rendered to the sugar industry and to the country highly valuable services in connection with scientific cane growing and technical sugar statistics.

Our members follow with real interest, and bring here each year the results of their observations for the information of all, in the agricultural aspect of the sugar industry, the progress of irrigation of cane, the selection of new varieties, obtained either by the acclimatization of seed from other countries or by the crossing of the foreign seed with typical Cuban seed, diseases of cane, systems of planting and cultivation, and finally, the application of chemical fertilizers to maintain the necessary metabolism of the earth, etc., all this with a view to reducing the costs of production and improving the quality of the cane.

In like manner study is given to the most efficient means of transportation, which in the present organization of the sugar industry, is one of the most expensive aspects, and with regard to which the Association of Sugar Technologists of Cuba has just presented a voluminous and well-documented report, which will be made known and discussed at this Convention, its intention being to continue its investi-

gations until it determines the most advantageous methods for the well being of the industry.

In the branch of mechanical engineering, study is being carried on of the principal aspects of grinding the cane, purification of the juice, evaporation, crystallization and purging, utilization of bagasse for allied industries, simplification of equipment for the process of manufacture, processes for distillation of molasses, or of juice directly, for obtaining fuel alcohol for motors, etc.

In the branch of chemical engineering, or of sugar manufacturing, we are obtaining advances of great importance in connection with the reduction of losses during the process of manufacture, in the improvement of the fisico-chemical and bacteriological quality of raw sugars which we produce for refining, and to this end principally, our members, who form a network which covers all the sugar mills of Cuba, are charged with experiments in the way of new processes and improvements to simplify present processes, until they obtain the economic production of sugar for direct consumption, perfectly refined.

We are all committed to that task, and to solve it we have available the facilities which are invariably furnished us by the mill owners and sugar companies, which have seen and proved that this Association represents the firmest and most effective column for raising the edifice of the new industry which promises, and which should produce sugar at a cost of 1.5 cents per pound on the basis recommended by modern conditions, to wit: intensive systems, mechanization of the industry, and better remuneration for labor.

But the problem which without any doubt whatever stands out most prominently among economic possibilities at the present moment, is that of the irrigation of cane, and to that end it appears to me to be but just to praise the act of one of our supermen in the field of national activity, Col. Tarafa, who foresaw the effects which the dissemination of Reynoso's volume "Experiments in Cane Cultivation" would produce among the sugar producers of Cuba, at the psychological moment when all the activities of the country are at their height to emulate the happy industry of the government, and in a gesture of patriotism caused the printing of thousands of copies of that book, the motto whereof is "Sugar Cane is a Plant Requiring Irrigation", and distributed it gratuitously throughout the country, as a good seed which would produce magnificent fruits. And we shall see those fruits, as it is a fact that throughout the country, from one extreme to the other they are working, studying and investigating in a manner never heretofore seen. The present reaction in favor of irrigation is due to the propaganda of Reynoso's book, and as that propaganda was conceived and paid for by Col. Tarafa, it is necessary to admit that this prospect of improvement in cane cultivation is due to Col. Tarafa.

This prospect means an increase of practically five or ten times the present production of a given area, that is to say, an increase of cane production from 30,000 arrobas to 150,000 or 300,000 arrobas per cab. At Centrals Jagüeyal, Cuba and Gomez Mena there are cases which confirm this prospect.

We are facing facts, and there is nothing like facts to convince us completely. But the change is so great, and the extraction to be obtained from the fertility of the soil so tremendous, that it is necessary to take elementary measures of prevision, in order not to exhaust the ground submitted to irrigation, and in any event to safeguard the economic industries of the manufacturing end of the industry, which

would inevitably be affected, if the mill were furnished cane of inferior sucrose quality. Ground submitted to irrigation needs to be properly fertilized to maintain the metabolism thereof, that is, the fisico-chemical equilibrium of its constituent elements. Cane is no more and no less than a factory in which Nature elaborates sugar, taking elements from the soil and from the atmosphere. The atmosphere is inexhaustible in its reserves, but the soil does not naturally or easily replace all the elements which it gives to the cane for its growth, and it is necessary, to maintain its fertility, that man provide the elements which it lacks. One cab of cane which produces 30,000 arrobas withdraws from the soil, approximately, one-fifth of the basic mineral elements, phosphoric acid and potash, which would be withdrawn by a production of 150,000 arrobas, and one tenth of what it would withdraw if production were 300,000 arrobas. How long would the fertility last, then, on a piece of land submitted to irrigation without the application of the proper chemical fertilizer?

If this requisite of artificial fertilization is not placed in effect jointly with the application of irrigation, the first one to suffer would be the mill, as it is evident that the quality of the cane will be reduced in proportion to the increased exhaustion of the mineral reserves taken out of the soil, and unquestionably the proportional quality and quantity of sucrose in the cane is the most important aspect for the economy of the mill. Irrigation requires, therefore, systematic chemical fertilization. At any rate, there is no question of the approach, because of the logical imposition of events, which are already a reality in the field of cane cultivation, of the necessity for modifying the present method of contracting for the purchase of cane on the basis of gross weight, establishing in lieu thereof the basis of analysis.

The planter who submits his lands to irrigation involving investment of new capital, expects to receive the benefit which, under the present contracts of so many arrobas of sugar for 100 arrobas of cane, will be produced by the increased production of cane per cab, without paying any attention at present to the quality of that cane, but for the mill which buys the cane from the planter the matter has exactly the contrary aspect, that is to say, either the present average richness of the cane will have to be maintained, in which case payment can be made of the same number of arrobas of sugar for each 100 arrobas of cane in proporcion to the reduction of its richness.

In either case the method is not equitable nor does it offer a means of easy understanding between the contracting parties.

There will not be the stimulus to produce cane of a superior quality in sucrose, at the same time that an increase in gross production is obtained, nor will the mill obtain any appreciable benefit if that quality is not improved each day, with the object of increasing the industrial yield of the mill.

By the observance of the present system of contracts, for more than 60 years, at least as far as we can prove by chemical analyses registered in official or private records, the average richness of cane in Cuba fluctuates between 13 and 15%, and it may be assured that instead of increasing it has diminished, a phenomenon which has not been properly noted, because of the increase which has been obtained in manufacturing yields, due to the chemical and mechanical advances introduced in the manufacture.

And it is not logical to expect any considerable improvement in the richness of the cane until the purchase thereof is effected on the basis of analysis, that is to

say, the sucrose or sugar content. This system of contracting offers the same advantages to the planter as to the mill, stimulating the former to make extra expenditures to improve the quality of his cane, as he knows that such an increase in quality will likewise obtain an increased payment which will compensate him for the investment made, and give an even greater margin of profit, and on the other hand, it will give the mill all the economic advantages of an increased industrial yield.

Irrigation, therefore, possibly affecting the richness of the cane if the elemental prevision of rigorous fertilizing is not followed, and even in other case surely affecting the industrial yield of the mill, makes it advisable to establish the purchase of cane on the basis of analysis.

This Association of Sugar Technologists of Cuba, at its convention of the past year, offered an ample and comprehensive study of the system of purchase of cane on the basis of analysis, presented by two of its members, Engineer Rafael Sánchez Aballí, initiator of the idea, whose activities in this matter will not cease until he has seen the system implanted in every mill in Cuba, and by the present speaker, also disposed to continue to insist in that same effort, and here, in full assembly, it was discussed with marked interest by planters, mill managers and mill owners, being afterwards unanimously approved. That study, therefore, has been one of the contributions of this Association of Sugar Technologists of Cuba, towards the improvement of the National sugar industry. Mr. Sánchez Aballí and the speaker later presented the same plan, with the addition of practical new formulas of easy application, to the Subcommittee on Agriculture of the National Commission on Economic Development, being likewise approved by all the members with the approving vote of the Secretary of Agriculture, General Molinet, who well knows, through long experience and from his knowledge of the development of the beet sugar industry in Europe and the United States, and the cane sugar industry in countries like Hawaii and Java, where the purchase of the raw material has always been based on analysis, the scope which its application will have in our country.

At this time the system has a general acceptance among planters, mill owners and the Government, and the progress of the cultivation of cane and of the industry in general demands it, not as a panacea having immediate effects, but as an equitable and solid basis for improving the quality of the cane, thus assuring an increase in the industrial yield.

In nearly every mill in Cuba there was established during the past crop the chemical control of cane by points of origin, and that practice, the utility of which has become evident to everyone, is the preliminary step taken toward the establishment on a definite and final basis in Cuba, of the system which we are eulogizing. The opportunity must soon come.

To improve the cane is to improve the quality of the sugar which we manufacture, and this condition must be met if we desire to defend the sugar industry of Cuba.

By the method of purchase of cane on the basis of analysis, we shall succeed, in a few years, in obtaining cane with 17 to 18 per centum of richness, with juices having a purity of 92 and 94, both conditions assuring a commercial yield of 15 to 16 per centum of sugar, the quality of which will greatly facilitate its distribution.

The Association of Sugar Technologists of Cuba will continue to press this matter, proposing new formulas and serving as arbitrator between the contracting parties when necessary and when its cooperation is requested, until its implantation has been obtained in all the mills of Cuba.

We expect in this manner to render a genuine cooperation in the work of general reconstruction, so happily and fortunately initiated by the present Government, and in order that this affirmation may be seen to be well founded I wish to state that there are now collaborating, in the ranks of the Association of Sugar Technologists of Cuba, on a task set them since its formation, real experts, men of eminence, internationally consecrated to the special features of cane cultivation, engineering and manufacturing, and other embryonic technical authorities who are already giving their valuable aid in this common effort tending to raise the scientific level of our principal industry, the basic industry of the country.

Our Association contains members of all nationalities. Titles of all the most famous technical universities and institutes of the world, and this heterogeneity of technical workers, in which those who most stand out are the graduates of experience and of practical work, which is the best of all schools, has succeeded in acquiring the consistency of a block of granite under the motto by which we are guided, and by which we shall continue to be guided, that is, Improvement of the Sugar Industry of Cuba.

The Sugar Technologists of Cuba are working actively and advantageously and as evidence thereof may be noted, in due time, the summary of the work of this Convention inaugurated to-day.

REMARKS OF PRESIDENT MACHADO AT THE OPENING OF THE SECOND CONFERENCE OF THE CUBAN ASSOCIATION OF SUGAR TECHNOLOGISTS.

I do not propose to make a lengthy address nor to discourse on any of the many technical questions which you have come here to discuss, because in the first place I wish to be brief, and, furthermore, I am lacking in special knowledge of the subject. I simply wish to thank you for having invited me to this conference, for the many courtesies which you have shown me here, and for the satisfaction it gives me to see you dedicated to a work so in accordance with my own ideals.

I believe with you that our efforts in the sugar industry should not be limited to producing more and more bags of sugar, and to launching these on the market, struggling in competition in the markets of the world, without ascertaining whether we are in as advantageous a position as possible. It is the purpose of this government to protect and help all industries that exist or may exist in our country; but principally the sugar industry, as it is our mainstay. I think that we should give it greater attention, more practical and careful attention. For this reason I am more than pleased to observe the direction you are taking, to see how you have worked and are working, and the enthusiasm with which you plan to continue your efforts in directing the first industry of Cuba towards a maximum of production and profit.

When I began my period of government I took a certain measure, advisable under the circumstances, but which to some gave a degree of alarm. There was no reason for this. Circumstances made it advisable at that time to restrict production, but this was not a definite, permanent measure; it was simply a temporary measure, adopted with the intention and the desire to be of some assistance. But this measure will not be used again, as circumstances now point to other steps. I am of your opinion now, and indeed I was of that opinion before coming here—that we

should intensify production in our main industry, always following, of course, a practical direction, working and knowing our work, and keeping always in mind that only with the application of technical knowledge can we obtain the greatest efficacy to our efforts.

First Mr. Guerrero and then Mr. Salinas have discussed really important points in reference to this new program. We should not limit our activities to fililing sugar bags and sending them to foreign markets, but should pay more attention to exploiting to the utmost the great prosperity which sugar can procure for us. It is necessary first that the soil, this fertile Cuban soil, which produces everything in such abundance, be made to give its maximum yield in the cane fields. I find admirable the measures which Mr. Salinas has proposed and explained in so masterly a manner. I also find worthy of every commendation Mr. Guerrero's proposal for exploiting all the richess that sugar cane can give us. We should direct our attention toward this end without loss of time, using all means at our disposal and sparing no efforts.

You may look for everything that you need from my Government. The government is not a mill owner. I do not wish to intervene in your problems, because I do not think that anyone is as well prepared as you yourselves to give them the proper solution. But, without interfering in your affairs, the Government should, must, in fact, offer you all necessary help, and you may rest assured that anything that you may request will be granted.

I have not aspired to the presidency of the Republic with the object of having my check sent to me at the end of the month. I do not need it, as I have always been able and willing to work for my living and have always obtained with my labor everything necessary to me. I have gone to the palace to work for my country, and I do not think I should spare myself any effort, any sacrifice in working for its welfare now, in times of peace, after having offered my life glady for this country on the battlefield. However, I should never consider effort or sacrifice anything that I am able to do for my country. The Presidency of the Republic is of value to me only if it enables me to labor and achieve for Cuba, and I despise the office if it means only gains and honors. As President of Cuba I consider that I have neither friends, family or political party. I have only open before me the way of honesty, to lead my country by this way toward the highest possible plan of well-being and prosperity.

In your sugar affairs I do not set a limit. If you need a law, ask for it, and my great collaborator, Congress, will vote it. If it is money that wou need, ask for it also, and if there is a dollar in the treasury it will go to cover that necessity. At this moment the Senate has under consideration a law relating to sugar, presented by Senator Clemente Vazquez Bello, here among us, which it has almost passed, but I am not content that this law should be discussed only by the senators, even though there are among them some who have technical knowledge. It is my wish that this proposed law be examined also by the members of your Association, and that you collaborate in it, as I think that this is the only way in which the law may be made perfect, absolutely perfect.

Continue your good work; do not be discouraged, and I repeat that whenever you need the help of the Government you may count on it. Work each day with faith and enthusiasm, and if Cuba is not a sufficiently wide field for your studies, I will open the doors of the world to you and will enable all those whom you yourselves may elect to go to other lands to study.

I said that I did not want to make a lengthy discourse, that I was going to be brief. I shall bring these few words to a close, but before doing so, allow me to make a request, although I have no technical knowledge to justify it. I wish you to grant me membership in your Association, to allow me to work with you for the good of our country, for its greater prosperity and for the definite fruition of those ideals which sent us not so long ago to the battlefields of Cuba.

General Eugenio Molinet, Secretary of Agriculture, Commerce and Labor, opened the Second Annual Conference of the Cuban Association of Sugar Technologists with a brief speech, mentioning the significance in the evolution of science and industry of specialization, "which means efficiency and progress." He stated that in line with the ideas of General Machado, he was trying to create technical experts in all branches of the Department of Agriculture, and that in order of importance the sugar experts naturally occupied first place.

SOME PATHOLOGICAL EFFECTS OF THE MOSAIC DISEASE OF SUGAR CANE

James A. Faris

During the spring of 1925 a comparative planting of mosaiced and non-mosaiced cane was made to determine several points of interest in regard to losses from the planting of mosaiced cane, effectiveness of rogueing in the control of the disease, manner and rapidity of spread of the disease, seasonal variations of spread, etc. The general report upon these experiments is not ready for publication at present, but one phase of the studies proved so interesting that they were followed up in more intensive experiments and it is upon this study that I wish to report now.

The first of the above comparative experiments was harvested in the Spring of 1927 as carried over spring cane, at which time the field planted from mosaiced seed had a very high percentage of dead stalks with dry tops. The dead stalks were so numerous in the diseased field that considerable difficulty was experienced by the cutters in getting the cane properly cut—a necessary measure for proper comparative studies. This was in great contrast to the check field which had very few dead stalks. The soil for these experiments was selected for its uniformity and hence the difference in the plants must be attributed to the diseased condition in the one plot and the healthy condition in the other. However, the tops and leaf areas in the mosaiced plants was obviously less than in the healthy plants of the check plot and thus it was suspected that the mosaic disease was dwarfing the root systems of the cane plants even more than the tops.

In addition to this very suggestive condition in controlled plots, a further group of conditions had been under study and observation in my study of conditions predisposing cane plants to root rot. Thruout the zones of heavy mosaic infected cane in Cuba, complaints of the root disease were more frequent. In fact it is precisely in these areas that our root troubles were most destructive. Field studies soon indicated that the mosaiced plants were much shorter lived than healthy plants, a condition most commonly expressed in terms of the limited number of ratoon crops obtainable from fields with high percentages of infection. However, the influence of the mosaic was not at all uniform, and in years of good rainfall

satisfactory crops are often harvested from fields of almost total infection. In fact, the areas of high rainfall are very favorable for the spread of mosaic, and for cane growth also, so that we have planters who tell us that their fields of highest infection are their best cane—"so if this is mosaic—give us more of it."

The mosaic situation first became critical in areas with marked alternating wet and dry seasons, that is where the spring and summer months were very wet—thus conducing to rapid spread of mosaic, and then followed by dry months, during which the diseased plants suffered severely from the drought. All of these observations again suggested that the mosaic disease might have a marked effect upon the root system. Dr. H. H. Storey showed the writer some photographs of Uba cane infected with streak, a virus disease similar to mosaic, in which the root systems of the infected plants were markedly dwarfed, in comparison to those of healthy plants.

Experiments were devised to determine whether the cane mosaic dwarfed the roots of the plants in a manner similar to the streak disease, and also to determine the relative weights of the roots, and tops of mosaic diseased and healthy cane Since the variety B H 10 (12) seemed to suffer even more than Cristalina cane when both were infected by the mosaic disease, both of these varieties were included in the experiments.

Plan of the Experiments

For the experimental testing of the hypothesis "that the mosaic disease has a marked effect upon the root system of infected cane plants", a well mixed potting soil was used. Pots 1 foot in diameter and 1 foot deep, well drained by bottom perforations and 2 inches of cracked rocks were filled ½ full of the potting soil, all of which had been brought to a uniform moisture content i. e., 60% of the water holding capacity. Seed cane of both healthy and diseased stalks were selected of a uniform size and then cut in uniform single—eye pieces. These were planted—one in a pot and covered with 3 inches of soil. The soil was of the chocolate

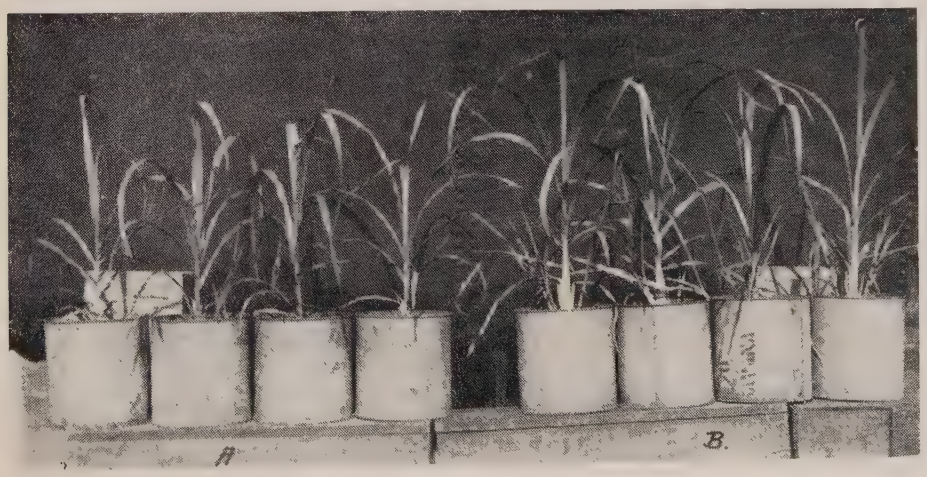

Fig 1.—Method of growing plants for these experiments. Cristalina cane three months old. A: Mosaiced seed used. B: Healthy seed and cane. Note the size, vigor and number of new shoots of the healthy as compared with the diseased cane. Figure 3 shows these plants with the soil removed from their roots.

brown phase of truffin clay which is very porous and drains very well. All watering was uniform for the experiments until the plants were two months old, at which time ½ of each lot was placed in a glass plant house and allowed to dry out considerably—just enough moisture being given to maintain growth for a period of two months, after which this series was well watered. The well watered series gave the most reliable results.

Beginning with the 2nd month, four of the largest of the plants in both the primarily infected plants and the healthy ones were selected, and all soil washed away from the roots. Since the seed piece roots and those of the young plants were so much tangled that it was impossible to separate them, all roots were carefully cut away at the stalks and seed piece, and weighed together. The tops were divided into stalk and leaves and their green weight determined separately. Since this division was arbitrary it is considered more reliable to use the figures for the tops and roots for comparison.

The following tables give the data for the period of the experiment.

DRY WEIGHT IN GRAMS

CRISTALINA CANE

	HEALTHY			MOSAICED		
Age of Cane	Tops	Roots	Total	Tops	Roots	Total
2 months.	66.5	26	92.5	31	13	44.0
3 months.	145	61	206	48	21	69
4 months.	199	80	279	161	66	227
5 months.	235	105	340	223	82	305
6 months.	324	111	435	271	115	386

B H 10 (12) CANE

	HEALTHY			MOSAICED		
Age of Cane	Tops	Roots	Total	Tops	Roots	Total
2 months.	55	22	77	28	12	40
3 months.	155.5	89.5	245	74	46	120
4 months.	255	119	344	118	65	183
5 months.	416	141	557	165	84	249
6 months.	483	141	624	235	100	335

There are several very interesting things brought out in this table. Note that the effect upon the Cristalina cane was very marked the 2nd month, the dry weight of the mosaiced being only 47% of the dry weight of the healthy and the 3rd month the difference being more marked as the dry weight of the mosaiced was only ⅓ of that of the healthy. The fourth month this difference was very much less, the weight of the mosaiced being 81% of the Healthy, the fifth month the mosaiced was 90% of the healthy in weight and the 6th month about 89% of the weight of the healthy.

This lack of difference in the last three months may be partially due to the roots of the healthy plants being limited somewhat in their growth by the size of the pots, while the mosaic plants, having less extensive roots at first could still extend in the soil. However, I believe that there is some indication that the Cristalina cane has ability to recover somewhat from the early handicap of mosaic under conditions of optimum water supply.

Fig. 2.—Cristalina Cane—2 months old—grown in pots. A Plants with primary mosaic. B Healthy plants.

Fig. 3.—*Cristalina Cane—3 months old—grown in pots.* A: *Plants with primary mosaic.* B: *Healthy plants.*

A B

Fig. 4.—B H 10 (12) *Cane 2 months old—grown in Pots. A: Plants with primary mosaic. B: Healthy plants.*

Fig. 5.—B. H. 10 (12) Cane—3 months old—grown in Pots. A: Plants with Primary mosaic. B: Healthy plants.

In the case of B H 10 (12) cane the end of the 2nd month's growth found the weight of the mosaiced plants only 52% of the healthy, the 3rd month this had been reduced to 49%, the fourth month 52%, the fifth month 45% and the sixth month 53%.

In the case of B H 10 (12) the percentage of weight of the mosaiced as compared with the healthy was very close to 50% thruout the entire experiment. If the difference in the percentages with Cristalina during the second and third months as compared to the following three months, had been due entirely to the Healthy plants becoming pot-bound the same should have happened with B H 10 (12).

From these data we have conclusive proof of a field observation in regard to Cristalina and B H 10 (12) canes growing under conditions of abundant water supply, that is, that under such conditions in this locality B H 10 (12) cane gives much heavier tonnage than Cristalina, provided both are healthy. If both have mosaic, Cristalina seems to give better yields than B H 10 (12). The first two months B H 10 (12) was slow in getting started and the healthy plants weighed less than Cristalina of the same age but the 3rd month and all subsequent months the healthy cane of the former weighed much more than that of Cristalina, while the last three months the mosaiced Cristalina weighed more than the mosaiced B H 10 (12).

Unfortunately B H 10 (12) cane has proven very susceptible to mosaic and hence in those regions of plentiful rainfall, precisely where it should be superior to Cristalina its planting would be rather risky in case such an area is one of rapid spread for mosaic.

Field Observations.

On October 1st and 2nd 1925 a planting of Cristalina cane was made in one of four experimental fields in Oriente Province in an area where cane suffers very greatly from root trouble induced by a combination of soil and rainfall conditions, as follows: The soil is one of our heaviest clay soils which sets like cement when it is dry and cracks into large blocks. The rains of this locality often come so constantly during the summer months that it is impossible to get the land dry enough to plow. For example; rains were so frequent that from July 20 to October 1, 1925 we were only able to prepare an acre of land for these experiments. The result of these conditions is to maintain the soil full of water due to the frequent rains, for 5 or 6 months of the summer, even though adequate run-off drainage is provided. This period of wet weather is then followed by one of drought in which the soils crack badly and the zone of the root system is limited.

In the experiment we planted 576 plants of Cristalina cane from healthy seed. Since the surrounding fields of cane had considerable mosaic, 117 of the plants became mosaiced by the end of the 1st six months. The subsequent record for these plants follows:

Of the 459 healthy, 189 have died or 41%
Of the 117 mosaiced, 87 have died or 74.4%

It is very clear from these figures that the mosaiced plants die out in a larger proportion of cases than healthy plants when grown under these rather *rigorous* conditions of soil and climate.

From field counts in several badly infected mosaic areas we have similar observations, in that missing hills are more frequent in fields of infected cane than in those

Fig. 6.—Mosaiced plant surrounded by healthy plants which are more than twice the height of this diseased cane. This mosaiced plant is shaded most of the day. Such plants often die out in the field.

of healthy. In one part of Oriente Province inquiry was made from colonos plowing up stubble in heavily infected fields whether or not they had noted any difference in the difficulty of uprooting healthy and diseased stools of cane. They were unanimous in saying that the healthy plants were much more difficult to plow up, and that the plowmen noted this at once.

A further difference between the healthy and diseased plants in the past experiments here reported was that the non-mosaiced plants produced many more tillers than did the diseased ones. This same condition has been observed in the field and no doubt is responsible for a considerable part of the field losses, in that the stand of cane is heavier on areas planted with healthy seed as compared with fields planted with mosaiced seed. (See figures 2, 3, 4 and 5). In some cases the mosaic cane appears quite as tall as the healthy, and in some of our Cristalina experiments was actually as tall (see figure 3). However, the lack of tillers, while not so serious in the pot cultures where tillering is limited, is a very serious loss in field plantings.

To sum up these results, we have here the explanation of the dying out of cane more rapidly in mosaiced plants than in healthy ones, due to the dwarfed root system; and also the reason for actual reduction of yields in fields where the mosaic-

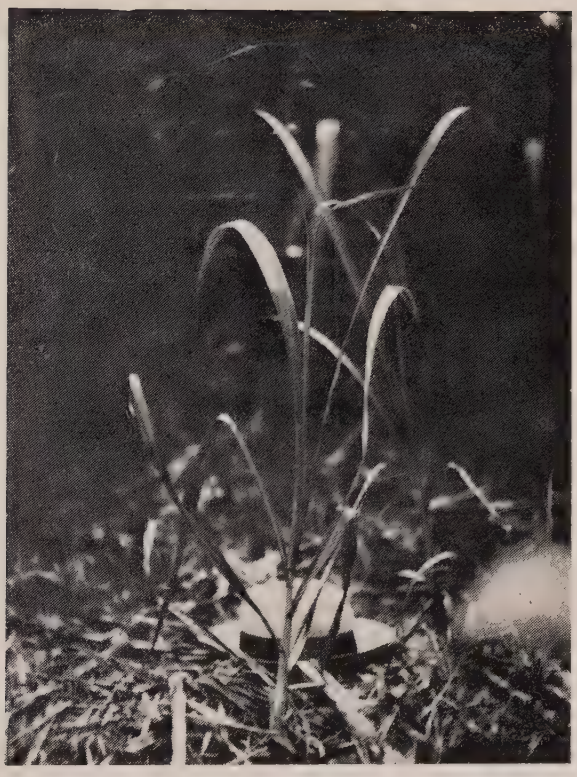

Fig 7.—Last living shoot of a mosaiced plant in the same field as shown by figure 6. This plant has since died out, resulting in a decrease in stand and also the field shows a lower percentage of mosaic due to the loss of a diseased plant.

ed cane appears to be quite as large as the healthy, due to the poorer tillering of mosaiced stools.

In addition we have direct proof of the seriousness of having mosaiced infected fields when a prolonged drought is experienced, even though field yields during years of adequate rains may be quite satisfactory.

THE STATUS OF THE SUGAR CANE MOTH STALKBORER IN CUBA

H. K. Plank

The moth stalkborer, *Diatraea saccharalis* Fabricius, has been looked upon in Cuba as a pest of sugar cane for a very long time. From 1862, when the first edition of Reynoso's Ensayo Sobre el Cultivo de la Cáña de Azúcar was printed, to 1913, when Houser's report on the borer was published by the Estación Experimental de Santiago de las Vegas, this insect became a generally recognized enemy of Cuban Agriculture and reports indicated a very apparent, though gradual, increase in its abundance and damage. After 1913, more definite information on the subject was accumulated by various investigators. Wolcott, in 1914, found an average infestation of 18.7% in standing cane at 26 places in 4 provinces; Salt found an infestation of 18.49% and a loss of 3,493 bags of sugar at Cen-

tral Soledad (Cienfuegos) in 1926; and Crawley reported in 1927 an average infestation of 15%, with a maximum of over 30%, and a loss of approximately 2% of the sucrose in total cane ground at 8 centrals in 2 provinces, in addition to the killing out entirely of some fields by the borer .

In 1926, Van Dine published in Bulletin No. 2 of the Tropical Plant Research Foundation the results of examinations made during the crop of 1924-25 at 11 centrals in the provinces of Havana, Santa Clara, and Camagüey. This, the first published record of a detailed borer survey in Cuba, gave more concrete and extensive information on the general status of borer infestation and the resulting loss to the Cuban sugar industry than any of the previous reports. The average infestation was found to be 19% for the 11 centrals. Attention was called to field losses such as reduced stand and consequent loss in yield due to non-germination of infested seed, the killing of the young shoots resulting in delayed growth and excessive stooling, in ability of the infested cane to withstand adverse conditions of drought and soil, and the reduced yield of harvestable cane brought about by the lighter weight of the infested stalks and the necessity of discarding those severely attacked or killed outright. For the purpose of determining the factory losses caused by the borer, comparative hand mill analyses were made of representative lots of borer infested canes and of sound canes. The juice from the infested canes was found to be 8.03% lower in brix, 12.27% lower in sucrose, and 4.57% lower in purity than the juice from the sound canes. Without taking into account the reduction in factory yield that these figures represent, but using only the sucrose loss of 12.27%, it is seen that the sucrose loss in all the cane having the average infestation of 19% was 2.33%. Based on a combined estimated crop of 2,885,000 bags for the 11 centrals, it was thus shown that the mill loss at these centrals amounted to 67,000 bags of sugar.

During the crop of 1927-28, the Station made another and even more extensive survey to obtain more detailed information on the loss at the mill and in the field. 14 centrals in the provinces of Havana, Matanzas, Santa Clara, Camagüey, and Oriente were included. The mill survey included the computing of the percentage of infested canes from each car as the cane from representative locations was passing up the carrier. At the 14 centrals represented, 365 cars of cane were sampled. These cars came from 228 locations in 43 different zones. Among the 35,143 canes examined, 12,688, or 36.1%, were found to be infested by the borer. Further, it was discovered that among the locations the average infestation varied from 0% to 98%, among zones from 4% to 69.9%, among centrals from 21% to 55.7%, and among provinces from 31.1% to 54.4%. These figures are very much higher than those reported for the crop of 1924-25, which showed an average infestation of 19% with a range among locations of from 0% to 94% and among centrals of from 8% to 32%. Four centrals included in the first survey were also included in the second. In 1926 they averaged 16.7% infestation, while in 1927-28 the average was 32.8%, an increase of 96.4%, or a little more than the percentage increase in the combined surveys. The percentage increase in borer infestation at three of these four centrals was over 120% of the infestation shown for them in the 1924-25 survey.

The field survey included the examination of representative cepas of standing cane in the field at 8 centrals in the provinces of Matanzas, Camagüey, and Oriente. The average density, or abundance of borer infestation, was found to be 8.3 infested stalks of harvestable condition per cepa, with considerable variation

in both directions. Since the internodes actually entered by the borer suffer the greatest loss of sugar, the percent of internodes infested in all stalks of harvestable condition, called the intensity of borer infestation, becomes a true indication of the severity of borer damage in this kind of cane. At these eight centrals there was at the time of examination an average stalk infestation of 57.3% in the field, and the intensity of borer infestation amounted to 9.97% of the internodes. 3.11% was the lowest and 20.97% the highest intensity found at any one central. These figures are extremely high and indicate a considerable loss of sugar through borer infestation. However, they do not tell the whole story.

In the field examinations made at three of the above centrals, located in the provinces of Camagüey and Oriente, all the dead or drying stalks which were large enough to be harvested but were either dry or too much spoiled by borer attack or other causes to be suitable for grinding, were sorted out and classed as "dry". The percentage of borer infestation in these "dry" stalks was then determined in the same manner as that in the stalks which were in good enough condition for sending to the mill. Analyses of the results of these examinations reveals the amount of cane which had to be left in the field on account of borer attack, a loss that heretofore has not been expressed in figures.

At the three centrals 112 cepas of cane, ranging in age from 7.4 to 28 months (average 14.4 months), were examined in a total of 20 locations. The "dry" stalks comprised 15.2% of the total number of stalks then of harvestable size. In these dry stalks it was found that the borer infestation was 73.1% and that, so far as could be ascertained, this infestation was the direct cause of the their disqualification. Hence 15.2 x .731, or 11.11%, of the stalks that were large enough to be harvested (that is, 11.11% of the crop) had to be left in the field on account of being infested by the borer. It was further discovered that 9.63% of the internodes in those stalks that were suitable for grinding were also infested by the borer. According to analyses made by Mr. Van Dine and reported in Bulletin 2, the average reduction in sucrose in the internodes entered by the borer was found to be 20.2%. Figured on this basis, the sugar lost in the harvestable cane found in these examinations amounted to 9.63 x .202, or 1.94%. Of course all the sugar that was in the 11.11% of stalks of harvestable size that had to be left in the field, was lost. This, with 1.94 lost in those suitable for grinding, makes a total crop loss of 13.05% caused by the borer in large cane alone.

It is probable that the most important factor which influences the status of the borer in Cuba is its natural enemies. Four insect parasites have been noted which at times kill about half of the borers on some plantations. Unfortunately, the effectiveness of these parasites is confined to certain seasons of the year when apparently favorable climatic or other natural conditions prevail. There are thus periods when most of th eparasites are comparatively inactive and the borer is left without any effective natural check. It we had parasites that would be active during these periods, we could expect that they would be at least as effective as those already present.

In many of the other cane growing countries of the world there are numerous borer parasites that could doubtlessly be introduced with profit to supplement the ones we already have. However, some of these parasites may be active only during periods when our own are also active and, thus overlapping, compete with them to the possible reduction of the effectiveness of both. Instead of this, we

need parasites that will fill in the gaps between our native species and thus complete the sequence of borer parasites throughout the year. In order to discover when the periods of inactivity occur, as well as the native species involved, the Station is making a thorough study of the entire situation throughout the Island

POKKAH-BONG AND TWISTED TOP DISEASES OF SUGAR CANE

C. N. Priode

A disease of sugar cane known as Pokkah-bong, which has been in Cuba for a number of years on the commercially grown canes, is attracting some attention at the present time because of its occurrence on the recently imported POJ varieties. The disease, so far, has not caused very much damage but should a combination of conditions occur, favorable for its development, it might prove to be somewhat destructive on the more susceptible varieties.

Symptoms of Pokkah-bong

This disease is characterized by the effects it produces on the plant tops. The first symptoms usually appear as chlorotic spots on the bases of the young, partially unrolled leaves. Red specks and strips usually develop on the chlorotic parts and in cases of severe infection may result in a wet rot. After the leaves separate from the leaf roll the red markings sometimes dry and fall out leaving holes and slits in the leaf bases giving them a ragged appearance. Such leaves usually break over and fall off. Where the infection penetrates to the young inner tissues of the leaf roll a top rot sometimes develops which may destroy the whole leaf roll down to and including the growing point. Usually, however, the younger leaves grow through the affected parts without being seriously damaged. In some cases the chlorotic spots on the leaves become wrinkled, corrugated and drawn and cause the whole plant tops to become twisted and deformed. Infection, in some cases, extends from the leaves to the leaf sheaths and produces holes and red markings similar to those observed on the leaves.

All the above symptoms may occur on the same plant, usually however, the chlorotic spots are the first and most conspicuous symptoms observed.

The disease usually makes its appearance soon after the beginning of the spring rains and continues its attacks throughout the rainy season.

Twisted Top

Another cane abnormality which heretofore has been confused with Pokkah-bong sometimes develops on certain varieties during the dry season. So far, its occurrence in Cuba has been so slight as to warrant little attention and it is of interest chiefly because of its being confused with Pokkah-bong.

This trouble, as the name implies, causes a twisting or malformation of the affected tops. The older leaves appear to be held together by some mechanical means and do not separate normally. The growth of the younger leaves from below usually causes the older leaves to split and tangle and these, in turn, have a tendency to wrap around and tie up the young leaves to that the whole plant tops usually grow into a tangled mass of split leaves.

Sometimes the younger leaves grow through the split older leaves but are so closely wrapped by them that they cannot unfold but grow into a slender spike-like mass of wrapped leaves.

Other cases may be observed where the spindles of the plants are not wrapped around by the older leaves but the tips of the leaves are held together and do not separate, thus forming arches as the growth continues from below. The tip of each new leaf, as it emerges from the leaf roll, becomes entangled with the older ones and a new arch is formed.

Plants affected only with Twisted Top show none of the chlorotic spots or red markings which develop on the Pokkah-bong plants.

Unlike Pokkah-bong, the disease occurs mostly during dry periods. Very few cases may be seen during the rainy season.

Causes of the Diseases

Pokkah-bong.

Experiments with the Pokkah-bong disease in Cuba proved it to be an infectious trouble caused by a fungus, probably the same species of the Fusarium fungus as was described in Java. Spores of the fungus, isolated from diseased material, produced typical Pokkah-bong symptoms when inoculated onto healthy plants.

In the field, the spores are bourne on the diseased plants and are carried by the wind and other mechanical agents to healthy plants where they germinate and produce new infections. The spores are produced in abundance during the warm rainy periods and infection is spread very rapidly on the more susceptible varieties.

Twisted Top

This disease, in Cuba, is a non-infectious trouble caused by the simple mechanical friction of the leaves. There are no symptoms connected with the disease which would indicate a parasitic origin. The occurrence of the disease in the field usually results from some injury to the plant which tends to increase the friction of the leaves, such as the abrupt bending or breaking over of the leaf spindles. These injuries may be caused by the wind, work animals or other agencies. Typical cases of Twisted Top were produced in experiments by artificially increasing the friction on the leaves through the abrupt bending of the leaf roll and by wrapping the leaf spindles with friction tape.

The occurence of the disease in the field is most noticeable during the dry season.

The water, during the rainy periods, apparently lubricates the plants to such an extent that the friction on the leaves is greatly reduced and the number of plants affected with Twisted Top is correspondingly lessened.

Varietal Responses to the Diseases.

Pokkah-bong.

The varieties of cane commercially grown in Cuba appear to differ greatly in their susceptibility to the attacks of Pokkah-bong.

Cristalina and D 109 are readily attacked but infection usually is restricted to the leaves and shows only as chlorotic spots and red markings. A few cases of top rot may develop but the loss on these varieties is usually very small. The varieties SC 12-4; F. C. 306; B H 10-12; Yellow Caledonia and some of the Porto Rican seedling canes also are susceptible but the attacks on these are usually very slight with little damage resulting.

Most all of the newly introduced Java canes are more or less susceptible to the disease. Of these, POJ 2878 appears to be most severely attacked. On the propagation plots of this station, where the overhead method of irrigation is em-

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in holes with two cuttings each, of sound POJ 2725 planted in alternate rows with 88 sets of sound B. H. 10-12 and 242 sets of mosaic infected POJ 36, not a single shoot of POJ 2725 became infected, while the B. H. 10-12 showed 73% of *infected stools*. He, therefore, referred to POJ 2725 as to a cane of notable immunity ("notable inmunidad"). Reporting from the Argentine Republic, Tucumán, Cross [2] classed (1926) this seedling as "almost immune to mosaic". He further stated that in Tucumán "if this variety is planted in the midst of mosaic infected canes, only a small fraction of the plants in each year take the disease, probably less than one percent." Davis and Saldaña [4], working in the Porto Rico Agricultural Experiment Station in the year 1925, observed that only "one-tenth of one percent of the crop of POJ 2725 had been affected by mosaic disease at Mayaguez." It is, therefore, generally known that these seedlings as a class are considered in Java, to quote Dr. Jeswiet's [8] own expression referring to the crosses of K. E. 28 x POJ 2364, (*) as "commercially immune against serch and mosaic". No detailed reports are known to the writer regarding the behaviour of seedlings POJ 2714 and POJ 2727 in relation to mosaic disease under Cuban conditions. Even regarding POJ 2725, actually the better known of these canes in Tucumán, Porto Rico and Cuba, there seems to be no experimental data available from experiences in this country.

In view of the scarcity of comparative information regarding the degree of immunity of these three seedlings among themselves and in comparison with our better known noble canes under Cuban conditions, the writer decided sometime ago to conduct some field experiment that would throw some light on the subject. It is the object of this paper, which is of necessity of a preliminary nature, to present the results of such trials as have been completed to this date in our trial plots at Central Palma.

EXPERIMENT A: To test the Transmission of Mosaic Disease by Secondary Infections in Varieties POJ 2714, 2725 and 2727.

In July 1st. 1927, two semi-grandbanks (*) each holding four rows of cane of 75 sets each were planted with sound cuttings of these varieties. There were two rows of POJ 2714, two of POJ 2725 and four of POJ 2727. The sets consisted of one two-eyes seed and were planted only one foot apart from one another in furrows 5 ½ feet apart. The plot is located in our old experimental grounds near the batey of Central Palma and was adjacent, up to recently, to: South, a small plot of mosaic infested Yellow Caledonia cane: East, plot of mosaic infested Cuba 35 and P. R. 710; North, a 25 feet wide plat of sweet potatoes; and West, a ditch across which there is some more POJ 2725 cane. About five weeks after planting, August 5, the plots were examined and no mosaic shoots found. A few replants were then made, to insure a full stand of cane. There were, thus, in these plots, by the end of August, 150 young plants of POJ 2714, 150 of POJ 2725 and 300 of POJ 2727, and no mosaic infections recorded during the month.

On September the 8th, the plots were again inspected and then some mosaic

(*) This reference applies, of course, only to POJ 2725 and POJ 2714 among the canes discussed here. Also to POJ 2722 in Dr. Jeswiet's article. POJ 2727 although carrying also 12½% wild blood through its Kassoer parentage had Batjan instead of E. K. 28 as its male parent.

(*) A modification of the Porto Rican "grand-bank" extensively tried by the writer in the low, flat, black lands of Cuba where the subsoil is of impervious clay.

infested shoots were found, all secondary infections. In no case was there any one "stool" entirely infested. The stools which had one or more stalks showing the leaf mottling characteristic of mosaic disease in these varieties, were recorded as "partially infected" stools. The number of infected stalks on each stool was also recorded and the individual mosaic canes tagged with metal labels for future reference. A map or plan of the planting was also made and each stool numbered from 1 to 75 along the rows, with the idea of marking the infected stools in the map as they were so found and tagged in the field.

The inspection of September 8, when the first mosaic infection were found, was recorded as follows:

Variety	No. of partially infected Stools	% Partially Infected Stools
POJ 2725	2	1.33
POJ 2714	2	1.33
POJ 2727	9	3.00

Monthly inspections were then made during the first week of successive months up to April 1928, when the plot was cut for seed for propagation and for further mosaic trials. The rate of additional secondary infections, as they appeared month by month, were recorded as tabulated below:

Variety	No. of partially infected Stools	% Partially Infected Stools
October 6		
POJ 2725	1	0.67
POJ 2714	2	1.33
POJ 2727	6	2.00
November 6		
POJ 2725	2	1.33
POJ 2714	0	0.00
POJ 2727	4	2.67
December 3		
POJ 2725	1	0.67
POJ 2714	1	0.67
POJ 2727	6	2.00
January 3		
No new infections found.		
February 8		
No new infections found.		
March 6		
POJ 2727	1	0.33
POJ 2725	0	0.00
POJ 2714	0	0.00
April 5		
No new infections found.		

A recapitulation of the total secondary infections noted up to this time, which was just about nine months after planting, would give the following secondary infection record:

Variety	Total No. of Partially Infected Stools	Total No. of Stools in Plot.	% Stools showing Secondary Infections.
POJ 2725	6	150	4.00
POJ 2714	5	150	3.33
POJ 2727	26	300	8.67

It should be noted, however, that these infections refer to stools showing more or less amount of secondary infection; that is, which showed one or more of *the individual stalks* with the leaf symptoms of the disease. In no case was the disease found to be *total* in one given stool, although in one case in one plant of POJ 2727 as many as six stalks were infected, there being only two apparently sound stalks in that particular stool. Usually, however, there were less individual canes per stool showing signs of the disease.

It is on this account that we have noted down the stools showing secondary infection or infections as "partially infected stools," since no stool can be called 100% infected until *all* its individual canes show the symptoms of the disease. This fact taken into consideration, the actual percentage of infection will naturally be considerably decreased in the case of these canes.

To prove this we counted the number of diseased stalks and the total number of each of the three varieties under trial, with the following results:

Variety	Total No. of Stalks	No. of Infected Stalks	% Secondary Infection
POJ 2725	1,050	10	0.95
POJ 2714	1,103	14	1.27
POJ 2727	1,802	125	6.93

It should be noted that the average number of canes per stool here recorded is less than is usually the case for these canes. This was partly due to the abnormally dry weather encountered during the trial and also, of course, to the close spacing of the planting.

There were also some abnormal occurrences met with during this trial, which may prove of importance in these studies:

(a) When only the sound canes were removed from some of the "partially infected" stools, the new shoots came up healthy as a rule and continued growing thus side by side with the older mosaic infected canes of the same stool. In very few cases, however, one or more infected shoots did come up among the generally healthy stubble canes.

(b) When the infected canes were also removed by cutting close to the ground with a sharp knife, the new ratoons shoots originating in these, did not all come up diseased, as would be the case with Cristalina or B. H. 10-12 canes; but on the contrary, a large proportion of the new shoots came up apparently sound, showing no signs of the disease.

(c) A stool of POJ 2725 (Set No. 23 of row No. 1) which had two mosaic infected stalks on the inspection of September the 8th, apparently *threw out the disease entirely*. The fading out of the yellow stripes characteristic of the disease were first noticed during the inspection of December the 3rd, and by February the 8th, no symptoms of the disease were noticeable in one of the stalks (Cane No. 1). By the end of March the other cane *tagged as mosaic* (Cane No. 2) *in this stool, had also thrown off all signs of mosaic.*

(d) The two individual canes of POJ 2725 canes "which apparently threw

off the mosaic disease" were cut into four seed-pieces each and planted on April 5, 1928. On germination, and after several inspections of the planting during the month of May, the following data was recorded:

Cane No. 1. (Four cuttings germinated sound.)

Cane No. 2. (Two cuttings germinated sound. One cutting germinated with one sound shoot and one infected. One cutting germinated three infected shoots.)

(e) The stool of POJ 2725 which produced the two above mentioned canes (Stool No. 23 in Row 1.) has been under close observation since it was cut on April the 5th. Up to the present time (June 9) this stool has produced nine stubble shoots and *none of these show any signs of mosaic disease.*

It should be mentioned here that our trial grounds at Central Palma are located in a highly infected district and that it is only through a continuous control campaign of rogueing diseased stools and replanting with sound cuttings, that such varieties as B H 10-12, S C 12-4 and Cristalina are maintained free from mosaic in our test plots. When left without rogueing, plats of these varieties have been seen to develop, even when planted with sound seed, over 50% of infection four months after planting. Presumably such plots would have gone close to 100% mosaic within a year, if left to grow without any repressive measures.

In order to test the infection of these canes under actual field conditions, in badly infected sections we planted also, in June 15, 1927 at colonia "Las Cuchillas", Central Palma, along the border of a field of young Cristalina stubble, a row of 235 sets (one cutting per set) of POJ 2714 known to be mosaic free. On the other side of the row there was a field of B H 10-12, also recently planted. Germination was excellent and 231 plants came up, all free from the disease. During the last week of July one set was noticed infected and by the end of October, when the field was lastly inspected, 32 sets were found with one or more stalks showing clear symptoms of the disease. This shows a secondary infection, calculated on the stools, of 13.8%. Adjacent fields of B H 10-12 and Cristalina canes, which were planted at the same time with mosaic free seed, showed at the time a general infestation fairly over 60%. No control by rogueing was being attempted in this colonia. The field was then about closed-in and was not inspected again until one month after the field had been harvested, May 20, 1928, when 34 of the ratoon stools were found having one or more mosaic shoots. None of the stools appeared 100% infected. The infection had actually increased from 32 to 34 sets, or from 13.85% to 15.15%. The general mosaic infestation in the Cristalina, B H 10-12 and Badila Canes in this colonia, is at this time very near to 100%.

However, in the same colonia, a much larger area of both POJ 2725 and POJ 2714 (3½ acres) which was entirely planted as a solid plot at the same time (June 15, 1927) did show a secondary mosaic infection of less than 1% by the time it closed-in and cultivation was stopped. The field was recently cut for seed and only a few canes were found with signs of the disease.

In Central América similar plantings of POJ 2725 have been made among very badly infected fields at "Colonia Naranjo" and only a few diseased shoots have been as yet found. In one case two rows of POJ 2725 have grown for a year side by side or rather in between parallel rows of highly infected B H 10-12, without as yet showing a single shoot which has contracted the disease.

More recently, after this data was compiled, we had occasion to observe the

following case of mosaic transmission in this same central: a field of POJ 2725 which was planted in the month of May, was supplied on July 15 with sound cuttings of the same variety and, in the said replant sets, the mosaic infection was up to 9.44% by the middle of November.

These are just "field experiences" not thoroughly controlled and are mentioned here to show the freakish conduct of the mosaic infection liable to be found by the cane growers now propagating these canes in Cuba.

EXPERIMENT B: To test the Transmission of Mosaic Infection through Planting of Infected Seed—Cuttings from Mosaic Stalks—in Varieties POJ 2725, POJ 2714 and POJ 2727.

Three mosaic infected canes of each variety, having marked leaf symptoms of the disease, were selected and cut into seed-pieces of two eyes apiece. Ten cuttings of each of these seedlings were thus planted in November 12, 1927 in adjacent rows. Side by side similar rows of ten infected cuttings each of varieties B H 10-12, S C 12-4 and Cristalina, were also planted. All sets were irrigated every two days, to insure germination, which was necessary on account of the lack of rains experienced at the time. The sets were examined as they germinated and all these showing mosaic symptoms were pulled out as soon as the infection was noticeable. In order to make sure that only primary infections—those originating from diseased cuttings—were counted. By the end of December 1927, or about six weeks after planting all the cuttings had germinated and the infection was recorded as follows:

Variety	No. of Cuttings Germinated	Number of Diseased Sets	% Transmission by Primary Infection
Cristalina.	9	9	100%
B H 10-12. . . .	10	10	100%
S C 12-4	8	8	100%
POJ 2714	10	7	70%
POJ 2725	10	6 ½ (*)	65%
POJ 2727	10	8	80%

The plants that germinated free from mosaic were cultivated up to May 20, 1928, without showing symptoms of the disease. The cutting of POJ 2725 which produced one diseased shoot and one sound one had the infected shoot removed by cutting down into the soil to include the half of the cane seed supporting it. The sound shoot was left in the ground and grown sound until destroyed on May 20, 1928. (This plot was located in the back-yard of the writers home and well isolated from mosaic infected cane.)

EXPERIMENTS C: A repetition of Experiment B.

Four rows of about 50 sets each were planted on April 5, 1928 in the following way:

Distance between the rows: 5 ½ feet
Distance between the sets along the row: 3 feet
Number of cuttings per set: 1
Number of eyes per cutting: 3

Three of the rows (Nos. 1, 2 and 3) were planted to POJ 2727 and one row (No. 4) part with POJ 2725 and part POJ 2714. The seed was obtained from

(*) One cutting germinated with one shoot sound and one diseased.

mosaic stalks cut from the canes used in experiment A; that is, canes that had contracted the disease by secondary infection but which have had the disease for several months.

There were at the beginning of the experiment, therefore, 160 sets of POJ 2727, 26 sets of POJ 2725 and 34 sets of POJ 2714. The reason for such small number of sets of the 2725 and 2714 was the lack of infected canes available at the time.

One May 26, germination and mosaic counts of this plot were carefully made and recorded as follows:

POJ 2727	Row No. 1	Row No. 2	Row No. 3	Total
No. of cuttings planted	55	55	50	160
No. of dead sets	4	3	5	12
No. of mosaic sets	11	22	11	44
No. of sound sets	40	29	32	101
No. of partially infected sets	0	1	2	3

We have in this case that of the 148 cuttings that germinated 44 showed complete primary mosaic infection, 3 were partially infected (*), and 101 did not show any symptoms of the disease. The percentage of transmission through the planting of *apparently infected seed* was therefore, only 32% even including the partially infected sets.

In the case of the other two varieties we have:

	ROW No. 4	POJ 2714	POJ 2725
	No. of cuttings planted	34	26
	No. of dead sets	4	4
	No. of mosaic sets	15	13
	No. of sound sets	15	7
(*)	No. of partially infected sets	0	2

These figures show also remarkably low percentages of infections transmitted through planting of cutting which, to the best of our knowledge, were infected with mosaic.

For the POJ 2714 — 50%
For the POJ 2725 — 68% (Including two sets which were only partially infected)

Before trying to recapitulate the results of the experiments discussed above, it would be well to survey "en passant" our actual knowledge of the behaviour of mosaic disease under similar circumstances in other varieties of cane. It must be made clear at the start, however, that our former experiences on the subject, as well as the references found in the literature the writer has had access to, are related to experiments with noble canes, of much higher susceptibility to the disease than the POJ seedlings used by us in our recent experiments. The bulk of the experiences with Cristalina and similar noble canes in the West Indies, since the year 1917, have thoroughly well established the following points:

(1) That Mosaic Disease is as a rule, an incurable disease; once infected a cane plant will remain diseased indefinitely.

(2) That infected seed-cuttings from mosaic infected stalks almost invariably produce diseased plants.

(*) These sets showed in two cases one shoot sound and one infected; while the other one had one shoot sound and two infected. These primary infections were very distinct.

As early as 1917 Stevenson [14] in Porto Rico reported results from a series of transmission experiments using infected cuttings from several susceptible varieties (Cavangerie, Otaheite, Yellow Caledonia, Stripe-Cheribon and Bamboo) advanced the idea that "all cane shoots springing from seed pieces which were cankered or mottled-leafed stalks will be diseased in spite of soil sterilization and desinfection of the seed. The fact that he mentions the soil treatment shows, nevertheless, that at the time Stevenson had not as yet recognized mosaic as an infectious disease. He further stated that "no instances of recovery had been noted once mottling appeared". A year after Profesor Earle [5], in a circular where he used the term "mosaic" for the first time in relation to the disease, admitted that cane mosaic was an incurable disease ("una enfermedad incurable"); while Colón [3], in the same publication, referred to the hereditary character of the disease stating that "almost absolutely, infected seed produced diseased cane plants" ("Casi absolutamente, semilla enferma de caña enferma").

In a subsequent paper on Sugar-cane Mosaic written a year after (October 1919) Earle [6] called attention to the fact that "it has been from the first recognized by all workers with this disease that it was hereditary, *that cuttings from diseased stalks quite uniformly produced diseased plants*". In a contribution from the Bureau of Plant Industry published about the same time (October 29, 1919) Dr. Brandes [1] admitted that "experiments in Porto Rico and elsewhere have repeatedly demonstrated that cuttings from infected stalks invariably give rise to infected plants." Brandes further on, in the same publication, mentioned that "the fact that has mostly impressed the Dutch planters (*) is that *cuttings from diseased stalks always produced diseased plants*...."

Up to the time when the last of the aforementioned publications appeared the concensus of opinion of experimenters in the American Tropics was, therefore, that sugar-cane mosaic was incurable and that diseased cuttings either "always" or "almost invariably" or "quite uniformly," produced mosaic plants.

The first report known to the writer relative to mosaic cane plants which recovered from the disease came from Hawaii, when Lyon [10] found that several infected stalks "threw off the malady entirely" and continued to produce new leaves which did not show further symptoms of the disease. These stalks, however, were not entirely free from infection, since when cut for seed and planted, the lower part of the canes which had held the older or mosaic blotched leaves produced diseased shoots. Only the upper part of these stalks, which sustained leaves "on which no blotches at all occured" did produce sound stools. Dr. Lyon's paper was published in 1921 and few years later (1924) Dr. Kunkel [9] reported the results of experiments conducted also in Hawaii during the years 1920-22, in which he discussed the first cases of "complete recovery" of individual stalks as well as of complete stools. In the same paper Dr. Kunkel observed "that diseased cuttings from certain varieties frequently produce healthy stools", although he admitted that "*for most varieties*, however, the disease is quite regularly transmitted through cuttings." It should be remembered that Doctor Kunkel's experiments were conducted with some of the noble commercial canes of Hawaii, mainly Striped Tip and Yellow Tip. His was the first reference that has come to the writer's attention regarding the varietal influence in the rate (or percentage) of transmission that may come about in susceptible varieties through the planting of cuttings from infected canes.

(*) Evidently this was the case with E. K. 28 and other noble canes grown in Java, before the POJ canes were developed with Kassoer blood.

During the year 1923-24, the writer, while working in Porto Rico, conducted some experiments [12] on the behaviour of mosaic disease in variety P. R. 333, with canes that had become infected by secondary infections and were subsequently used for seed. No case of recovery had been as yet confirmed in Porto Rico and the transmission through infected cuttings was considered either "quite uniform" or "invariable" by the various workers in the island. The writer had had at the time no proof of a diseased cutting producing sound shoots, but he admitted the possibility of such occurrence, in view of the fact that in several occasions he had observed, while rogueing mosaic plants in fields of young plant cane, cuttings which apparently had produced both sound and diseased shoots. The experiments with seedling P R 333, a very susceptible variety, did not point in this direction, however, since, even cuttings from the lower or butt part of cane stools with recent secondary infections, and therefore, showing only a few of the upper, young leaves mottled with the yellow stripes of mosaic, gave invariably diseased shoots. The author at the time concluded that the mosaic infection, at least in variety P. R. 333, travels down the cane stalk infecting the lower cuttings even though these have not at anytime shown symptoms of the disease. We called attention at the time to the fact that our experiences did not agree with those reported from Hawaii.

The most recent reference to the subject known to the writer, has been that presented by Hansford [7] from Jamaica, who reported (1926) that experiences in that island fully agreed with our experiences in Porto Rico and that "no case of recovery from the disease has been proved" in that island.

Such is, therefore, the actual status of our knowledge regarding the behaviour of mosaic disease in the noble canes. In the three POJ seedlings tested in our recent experiments the mosaic infection has behaved in a way quite different from our former experiences with other varieties. Evidently these Kassoer descendants, although at times get infected with the disease, have enough admixture of wild blood to account for their relative immunity and for the freakish nature of the behaviour of the mosaic infection in diseased plants of these varieties.

From the results of our aforementioned experiments and experiences, may be advanced the following points regarding the behaviour of mosaic disease in these three POJ. Canes, under open field conditions in Oriente Province.

(1) Considering Cristalina as 80% susceptible, the relative susceptibilities of these varieties to secondary infection may vary, from less than 1% under usual field conditions in Oriente, to rarely higher than 10% under the most favorable conditions of spread.

(2) POJ 2727 seems to be more susceptible to secondary infection than both POJ 2714 and 2725.

(3) Insofar as these canes are concerned, *mosaic is not always an incurable disease.*

(4) Mosaic infected cuttings of these varieties *do not generally give rise to diseased shoots;* in fact, infected cuttings seem to have an even chance of germinating healthy.

(5) Stubble shoots from infected stools *may or may not come up showing signs of the disease.*

(6) Although so little susceptible as to be in reality practically immune to mosaic, these canes *do not seem to be so very highly tolerant* to the disease once infected; since the individual infected stalks often show the usual signs of slow vertical

growth and of general stunted condition characteristic of the disease. Such seems to be decidedly the case in POJ 2727, which in our plots even developed the constricted internodes and "canker" marks characteristic of the advance stages of mosaic disease. This was observed in diseased stalks six months after they had become infected. These effects are often as marked in mosaic stalks of POJ 2714, but much less so in the case of POJ 2725.

In the light of the above results those Cuban planters interested in propagating these POJ seedlings would do well in remembering that these canes are not really immune and do not constitute, therefore, a fool-proof way of stamping out mosaic disease from highly infected districts. With very little effort, however, they can be kept entirely free from the mosaic infection; thus making it possible, with the time, to gradually salvage mosaic ravaged zones, eventually freeing them completely from the disease. The fact that these canes are almost immune does not mean that they can be planted in badly infected districts and abandoned to their fate without danger of becoming considerably infected. Our experiments seems to indicate that this danger may at times be greater than it is generally thought. It will be very easy, however, to maintain the fields of these varieties almost absolutely mosaic free, at a cost that will be negligible, in comparison with the expense of control by seed selection and rogueing in new plantings of susceptible varieties such as B H 10-12, S C 12-4 or Cristalina.

A sound stool of POJ 2714 grown from an apparently diseased cutting.

Plot of POJ canes planted with infected seed and more than half of which germinated without signs of the disease. — The stools marked with the stakes and white tags are sound.

Sound stool of POJ 2725 which germinated "partially infected." The shoot with white tag showed a clear case of primary infection, while the other shoot from the same cutting came up sound.

A stool of POJ 2727 in which one shoot only came up showing a clear primary infection, while all the others appeared sound.

Sound stubble shoots growing around infected canes of POJ 2727.

A stool of POJ 2727 "partially infected" with mosaic disease. ~ Most of the stubble shoots germinated sound; but some showed clear primary infections. ~ One of the old canes appeared much stunted and had "canker marks" of the disease.

constricted internodes due to mosaic disease

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IRRIGATION OF SUGAR CANE

P. V. Goldsmith

Over 50% of the sugar cane area in the Hawaiian Islands depends on irrigation and the tonnage produced on the irrigated area is over ⅔ of their total sugar crop.

In Porto Rico large areas are also being successfully irrigated.

In Cuba, while the temperature and uneven character of the precipitation make conditions just as favorable for irrigation as in Hawaii or Porto Rico, it has never become a general practice here except in a few isolated cases. One of the first installations in Cuba was made at Central Constancia of the Cuban-American Sugar Company in 1912.

The area under irrigation, at the present time, comprises about 75 caballerías of red and mulato soil.

The soil is mostly Matanzas clay with some admixture of Trujillo clay, especially in the lower areas. The top soil is of good depth but very open and porous to [illegible]

ture. Practically all of the soils in this area are underlaid with a white or yellowish lime rock.

Previous to the installation of irrigation, this area had been found by experience to be too dry for successful cane growing except in certain small areas, or in years of abundant rainfall.

The source of water is from driven wells, several of these wells being connected to one pumping unit. The average lift is about 15 feet.

The pumping units are of the rotary type and are driven by gas engines burning producer gas. There are four pumping stations with a total capacity of 34,000,000 gallons in 24 hours.

Oweing to the porous nature of the soil, the average loss of water thru seepage is about 40%. This reduces the available water from 34,000,000 gallons in 24 hours to about 20,000,000 gallons.

It is very easy in irrigation work to disregard natural water losses and extend the area to be irrigated beyond that for which one has an adequate supply of water, especially at the time of maximum requirements, "peak load." In this case much valuable time and money are lost, and projects which should have been a success prove failures. To much stress cannot be laid upon this point. The irrigation of sugar cane like any other cultivated plant, is very similar to the so called "forced feeding" of animals. Success in both cases depends, not only on the quantity and quality of food given, but particularly upon the regularity with which it is given. Any break in the program, once started, means impared efficiency.

In the preparation of irrigated land for planting it is very important that it be broken as deeply as the soil type will allow. Where the areas are large enough to permit, the Fowler steam plow outfits are ideal for this work.

After breaking the land we find that sub-soiling or "knifing" is very benificial as it breaks up any hard pan which may have formed as the result of the irrigation water carrying the finer soil particles down below the normal furrow depth. The operation of "knifing" when properly done increases the water holding capacity of the soil and enlarges the root zone.

In the "Furrow" system of irrigation the cane is planted in deep furrows and covered, the balance of the open furrow above serving as a channel for the irrigation water. In this system it is very assential that the furrows be made as deep as possible. For this work we find nothing better than the furrow openers as supplied with the Fowler cable plow outfits. These machines not only leave a perfect furrow as to width and depth, but do the work rapidly.

The water courses which supply the furrows with water should not be more than 30-36 feet apart otherwise the cane at the end of the furrow where the water enters will receive too much water. They should be built up as high as possible above the furrow levels in order that there will always be a sufficient head of water to irrigate the whole length of row.

The furrows in the "furrow" system will be found to filll in gradually but if propertly made and cared for they should serve for at least two ratoon crops. In this regard the importance of deep furrows at the beginning cannot be overestimated, as well as the making of the water courses as high as possible, otherwise as the furrows fill in the head of water decreases and irrigation can only be accomplished with great difficulty.

In practice with the "furrow" system it sometimes happens that the furrows become filled in after the first ratoon crop to such an extent that the application of

water in the row is rendered difficult or impractical. In this case the trash can be turned to alternate middles and a water course opened down the center of the cleared row. This system of irrigation is known as the "every other row method." While this results in a considerable saving of water it does not give as large yields as the furrow system.

We have found that the burning of the cane trash on irrigated fields has always resulted in smaller yields due, evidently, to a damaged cepa. The practice has been abandoned.

The question of cane varieties has a very important bearing on irrigation. With the advent of such varieties as B H 10 (12) Santa Cruz 12 (4), POJ 2725, POJ 2714 and POJ 2727 we find that they respond much better to applications of water than Cristalina, due probably to a stronger and better developed root system. These new varieties mean greater tonnage with the same expense for irrigation.

In planting cane for irrigation one of the most important things to be considered is the amount of seed. At the present time we are planting continuous row, (chorro) with a distance of 5 feet between rows. We are also making experiments in which the amount of seed in the row is increased by one-half, (chorro y medio). In irrigation we must not loose sight of the fact that it is an "intensive" system and that we must get tonnage oven at a sacrifice of large size canes and long life ratoons.

As soon as the cane has been planted we give it a light application of water. This is followed by a second application within 10 days. These two irrigations during the first 10 days after planting are very important and essential to rapid germination.

After the first 10 day period water is applied to the cane on the average of one application every 15-20 days, provided the rainfall does not exceed 1 to 1½ inches in any one rain. These applications are continued up to within a month or six weeks of harvest when all irrigation is suspended in order to allow the cane to ripen.

In the practice of irrigation the water should be applied at regular intervals depending upon local conditions of soil moisture, periods of rainfall and the natural "growth period" of the cane.

The soil moisture should not be allowed to drop below 25% for best results. If it falls much below this point wilting usually occurs. The leaves of irrigated cane should never be allowed to curl from lack of water. If irrigation is witheld until this point is reached the growth of the cane will have been retarded.

In irrigation it is important that the water be so applied that the cane will receive the greater proportion during its natural growth period. During the winter months, when the growth is naturally retarded, less water should be given than during the spring and summer months when growth is at a maximum. Endeavoring to force the growth of cane with heavy applications of water during the winter months not only results in a loss of water but may damage the plant itself.

The amount of water which the cane receives per application varies from 2½ to 3 "acre" 'inches, (One acre inch equals 27,154 U. S. Gals.) The total amount of irrigation water which the cane receives per crop of 12 months is approximately 50-60 acre inches. If we add to this the average yearly rainfall (50 inches), the cane receives then a total of 100-110 inches of water per year.

In applying irrigation water it is important that the laborers be instructed to maintain the "furrow" and water courses. Too much stress cannot be laid on this point and "eternal vigilance" in this regard is imperative.

In all weeding operations the dirt should always be moved out of the furrow to tha ridge between.

We have found at Constancia that irrigation by "journal is much more satisfactory for this class of work than is "contract" labor and less expensive in the long run.

It will be found that the first application always consumes more time and water than do subsequent applications due to the necessity of building up water courses and also to the fact that the newly prepared land absorbs more water than it does later.

The constant leaching of soil where irrigation is practiced generally makes the use of commercial fertilizers essential. In so far as our experience goes a complete mixture carrying all three of the essential plant feeds viz., nitrogen, phosphoric acid and potash gives the best results.

The fertilizer is applied at the rate of 10 tons per caballeria, ½ in the furrow at planting and the balance 4 to 6 weeks later.

Some economy is undoubtedly gained by dividing the fertilizer application into two or three parts, especially the nitrogen; however, an early application is absolutely essential and for this reason at least ½ should be distributed in the furrow when the cane is planted.

In irrigating sugar cane the error is often made in endeavoring to obtain too many cuts from one planting. As the age of the cepa increases its power of economical response to irrigation or fertilization becomes less. Good judgement is necessary, therefore, in selecting each year only those fields for irrigation and fertilization which will pay for their keep.

NOTES ON IRRIGATION EXPERIMENT CENTRAL JAGÜEYAL, PROVINCE CAMAGÜEY

A. W. Turner

In presenting the experiences and observations made during the time that we personally conducted the irrigation experiment in Central "Jagüeyal" we are not attempting to point to the solution of the problems of the sugar industry by the widespread use of irrigation, but present this data merely as our contribution in the investigation of one of the phases of the problem.

The soil selected for the experiment was of the light polvillo Matanzas clay, having, as soil of this type, very poor water-holding capacity. According to Mr. Ageton, this soil has a retention capacity only of 37% and considering that 25% is the safe margin for maintaning growth, the difficulty of keeping this soil moist may be appreciated.

The greatest obstacle encountered in the actual work was the large % of water lost by seepage and by the uncovering of subterranean passages (casimbas) and old ant hills, causing a loss as high as 44%. This means that at times nearly half of the water pumped did not reach its destination. Another lesser difficulty was the training of the laborers.

Because of the seepage, though the actual application averaged 5.68 acre inches, which is reasonable in this kind of soil, the cost of water seems abnormally high, for the basis of cost calculation is on water pumped and not on water used; thus we find that we pumped 266,543,352 gallons but had available for the field use only 158,859,958 gallons; the total gallons pumped give an average application of 9.54 acre inches.

The seepage has been cut down from 44% to 17% by the use of a three per cent solution in the main ditches of commercial caustic soda (NaOH). Unfortunately this sodalay solution was not applied, and then only partially, till the ninth and tenth irrigations. The cost of applying the solution was charged directly to irrigation, the saving in water being ample to cover labor and material charges. The water losses were ascertained by the use of a portable Cipolletti weir and can be taken as nearly exact. Ditches after the sodalay application were allowed to empty out into the roads, water being tested before resuming irrigation. This was done in order to prevent the irrigation water from carrying toxic proportions of NaOH into the cane fields. The amount of water used for washing was negligible.

The success of our seepage reduction was doubtful only by our lack of knowledge on the duration of the effect on the ditches of the soda solution. As shortly after application there was suficient rainfall, irrigation was temporarily discontinued, nevertheless we were greatly encouraged to note that two months after treatment the ditches were holding the rain water for 72 hours while the untreated ditches were dry in less than 12 hours after heavy rains.

The plant-cane has been irrigated on the cane furrow itself, making the even application of water very difficult due to the trash and cane interfering with the water, and with the partial breaking of the sides of the furrows the irrigation at times is nearly of the flood type. We find that the average area handled by one man, per day of eleven hours, is 0.80 acres. Though this figure seems disappointedly low, comparison with Hawaii "Ewa Plantation" figures comprising several years time which gave an average 0.72 acres per day man, shows our attainment not far from normal. On our earlier irrigations when the canes offered less obstruction to the water, one man covered 2.41 acres per day. This figure of nearly two and a half acres will be approached as an average with our ratoon irrigation where we plan to irirgate alternate furrows and where the cane is not on the watering furrow.

In commenting on the results of the experiment, it seems necessary to emphasize the showing of varieties and comparing this showing with that made by our standard cane, the cristalina. We planted about 4 cordeles each of B H 10-12 and S C 12-4, also some single rows of Badila, POJ 2725 and H 109. No attempt was made to record the arrobas per caballia of any but the cristalina, the B H and the Santa Cruz. Though these canes were cut for seed, a careful weighing and measuring was done in order to arrive at a true comparative result. All canes taken out from each variety were weighed and a load of each cane was stripped and topped as for the mill; in this manner we found the % trash and top to be discounted:

		Hand Mill Analyses.		
VARIETY	@ per cab	Brix.	Sucrose	Purity
S. C. 12-4	78,170	19.35	17.20	88.89
B. H. 10-12.	96,560	20.22	18.52	92.14
Cristalina.	53,075	20.00	17.79	88.95
Cristalina (unirrigated) Calculated.	20,000	21.40	18.17	87.71

This test was taken with the cane at ten months old, the three irrigated lots having received identical attention in irrigation water, cultivos and abono. The not irrigated plot had every treatment the others had but no water other than rain fall. Thus we find that had the whole area been planted to one variety only we would have had:

3 cabs 55 cords planted in—

Cristalina . . . at 53,000@ per cab. would give 167,996@
BH 10-12 . . . at 96,000@ per cab. would give 304,296@

S. C. 12-4. . . at 78,000@ per cab. would give 240,901@

Further than the arrobas per cab. the cristalina has failed in spots in our fields even after extra attention was given it in regards to water, fertilizer and extra cultivo. These same spots have been planted to BH Santa Cruz and POJ 2725 and up to the present are doing well. Another advantage of the BH and other seedling canes over our cristalina can be deduced by study of the periodical growth chart where cane reaction to differing conditions may be observed. The responce of the seedlings to favorable conditions of growth is more rapid in manifestation than the responce of the cristalina, whereas the inverse is also noted in respect to adverse conditions. The explanation of this bad feature is had in that the root system of the cristalina is not as well developed as the other canes, for after irrigations, with slight winds, at times merely by the weight of the canes, the cristalina stools would topple over uncovering a shallow root system. The seedling canes mentioned though heavier than the cristalina were not overturned after irrigation, nor after winds that had damaged some cristalina stools. In some cases the canes would break off at the ground level, specially the POJ 2725.

The whole story of the greater tonnage of the Barbados Hybrid is not apparent from the total growth chart, for by these measures we would place the Santa Cruz in first place. On an investigation, during the month of November of last year where the average girth as well as the number of canes per linear meter were tabulated, we found the girth order was as follows: Cristalina, Santa Cruz, BH and POJ. But that in the number of canes per meter the BH 10-12 was far ahead with POJ Cristalina and Santa Cruz following in order.

When harvested for seed the canes were cut leaving the young shoots that would not give seed. While we observed that both the Santa Cruz and the Cristalina had renuevos of various age from several feet to a few inches, the B H 10-12 had the shoots uniformly small. It is evident from this that a hand mill test would not be a good method of comparing canes of such different habits, and that a cane with an even growth would produce an even juice, easier to work in the House and giving a higher % of recoverable sucrose.

The pumping system is of the Worthington Coniflow type with a rated capacity of 1500 gallons per minute. Out side of slight trouble with the pump due to an improperly placed bearing, the pump gave efficient work. Motive power for the pump was furnished by an electric motor.

Total irrigation water applied (actual) from the start till tonnage test was made, amounted to 56.80 acre inches with a rainfall for the same period of 39.60 inches, or a total of 96.40 acre inches per that crop. Dr. Crawley opines that for Cuban conditions 125 inches should be ample to produce a crop. Calculating on this basis we are short 28 inches. A comparison with Hawaii, where W. P. Alexander claims an average of 19.03 acre feet or 228 acre inches are needed for a full crop, we can assure with our more favorable climatic conditions, as heavy crops can be produced, but naturally irrigation in larger amounts must be used.

From comparative costs, even though incomplete, for our figures only spanned a short time, the weather being adnormally dry, we feel that irrigation is commendable, with careful soil selection, and planting the more adaptable canes. In compensation to our greater cost we have greater tonnage; the assurance, independently of rainfall, of a concentrated supply of cane, which cuts down the rent we

pay on lands as well as the hauling costs; with the advantage of rapid propagation of seed cane at short notice of a good healthy condition.

However while by increasing the production per cab we reduce the cultivation cost per 100@ as well as deriving the advantages mentioned above, our cost of harvesting remains the same because of our present system of paying a more or less fixed rate per 100@ of cane harvested.

While some advocate, experiment, or practice the mechanical cultivation; mechanical cane cutting; introduction and propagation of seedling canes; soil treatment; control of epidemic diseases; irrigation, and other phases, we must have in mind that no one of these methods employed singly will solve our pressing needs, but that rather the solution is had by the practical and coordinated combination of the different improvements from which the ultimate goal would be the maximun production per unit of surface, with the minimum cost per unit of weight.

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LABORATORY REPORT ON WATER ANALYSIS

Lab. No. W 1. Date of report: June 21, 1927.

Locality: Central Jagüeyal.

Source of sample: Distribution tank irrigation project.

Taken by: Mr. Turner. Date: May 19, 1927.

Analysis:

Total Solids	645	parts. per million
Silica and insoluble matter	19	,, ,, ,,
Iron and Aluminum Oxides	4	,, ,, ,,
Calcium Oxides	166	,, ,, ,,
Magnesium Oxide	77.4	,, ,, ,,

Method of Analysis: Methods of Analysis of the Association of Official Agricultural Chemists.

LABORATORY REPORT ON WATER ANALYSIS

Lab. No. W 3. Date of report 8/23/27.

Locality: Central "Jagüeyal".

Source: Distribution tank irrigation project.

Taken by Mr. Turner.

Analysis:

Total Solids	677	parts. per million
Silica and insoluble matter	19	,, ,, ,,
Iron and Aluminum Oxides	4	,, ,, ,,
Calcium Oxide	153	,, ,, ,,
Magnesium Oxide	203	,, ,, ,,
Cholorine as Sodium Chloride	110	,, ,, ,,
Sulphates	12.7	,, ,, ,,
Carbón Dioxides as Carbonates	42.24	,, ,, ,,
Carbón Dioxides as Bicarbonates	232.32	,, ,, ,,

Method of Analysis: Methods of Analysis of the Association of Official Agricultural Chemists.

INTRODUCTION TO THE SUBJECT OF SUGAR ESTATE RAILROAD OPERATION AND MAINTENANCE

M. J. Leonard

This year for the first time the Association of Sugar Technologists have thought it convenient to name a Committee to present some of the aspects of Transportation to its members, and to this end, two papers have been prepared, one with reference to the repairs and maintenance of equipment, and the other about the broader subject covering the movement of cane from the fields to the Centrales.

We had hoped to give you a third paper dealing with the latest developments and economies of tractor haulage of cane, but because of the unavoidable absence of the gentleman who had kindly consented to prepare this thesis, we are obliged to delay its presentation until some later meeting.

While the amount of money spent by any one sugar estate or even by the industry as a whole, in Transportation, is relatively small, as compared with the enormous expenditure in Agriculture, and considerably less than the total outlay in the Manufacturing Department, you will, I believe, be somewhat surprised to know that the total annual expenditure in the sugar industry in Transportation, nevertheless, amounts to something like $50,000,000 taking as a basis a normal crop of 5,000,000 tons of sugar. This, of course, includes maintenance of road and equipment, also freight of public railroad lines for sugar as well as cane, and the cost of hauling the cane from the fields in carts to the mills or loading stations.

It does not include, however, the cost of freighting the sugars from Cuban ports to the United States, which would account for another $14,000,000, or a grand total of $64,000,000 which the industry spends annually in Transportation in one way or another.

The estimated invested capital in the sugar industry is about $750,000,000. A fair valuation of the present railroad lines, locomotives and cars of all sugar estates on the Island is about $120,000,000, or one sixth of the total.

A word about its physical proportions. If all of the private railroad lines of the private railroad lines of the Island were consolidated, we would have a system comprising over 12,000 kilometers of track of all gauges, owing 35,000 cane cars, 2,000 box, tank and flat cars, and about 1100 locomotives. The kilometrage of track is equivalent to the distance from Habana to New York, and from there to San Francisco and return, and if we were to include the public railroads of Cuba which amount to over 6,100 kilometers, the total would amount to 18,100 kilometers, or the equivalent of one mile of road for every four square miles of national territory. The United States with about 260,000 miles of track and a total of all lines including yards, switches, and sidings, of 400,000 miles, has one mile of track for every seven and a half square miles of American territory. Cuba, therefore, has very nearly twice as much railroad per square mile as the United States.

Cuban sugar mills have equipment capable of handling 500,000 tons of cane daily, using each car only once during each twenty four hours. The average locomotive hauls twenty cars per trip with an average load of about twenty tons of cane. As the average haul is about 15 kilometers, we find each locomotive hauling the equivalent of 6000 tons of cane one kilometer each day.

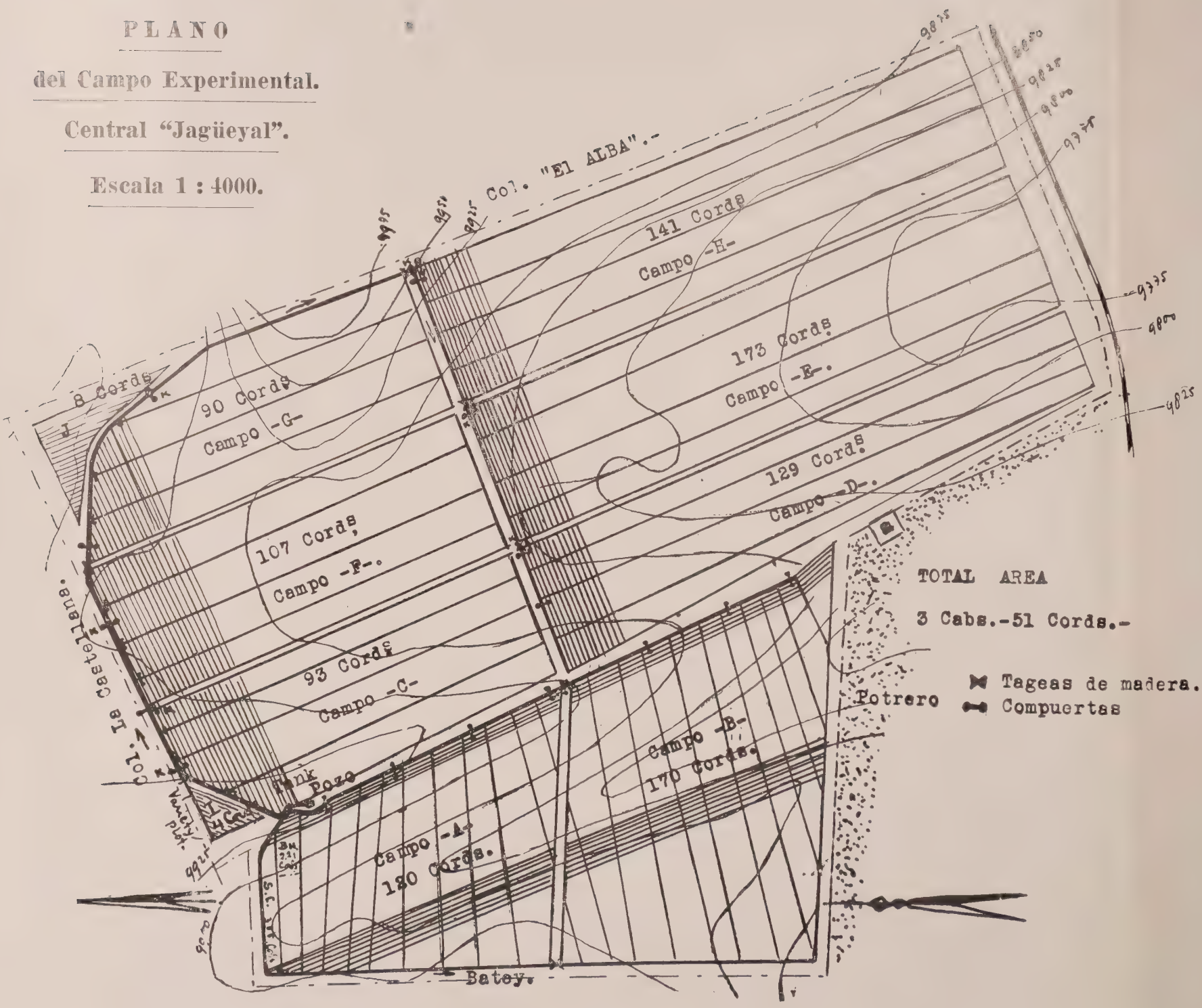
Excluding field labor there are approximately 50,000 men employed in the sugar industry of this country. Field labor is excluded in this survey. Over 30% of this number, or about 15,000 men are employed in the operation and maintenance

PLANO

del Campo Experimental.

Central "Jagüeyal".

Escala 1 : 4000.



CUBA CANE SUGAR CORPORATION
ENGINEERING DEPARTMENT
HABANA

CENTRAL JAGÜEYAL
TOTAL GROWTH OF IRRIGATED PLANT CANE

CHART NUMBER

CM

300

200

100

75

50

25

- CANES -

Sta. Cruz 12-4 — . — . — . —

B.H. 10-12 — .. — .. —

Cristalina ———————

Cristalina (unirrigated) . . . . . .

5 10 15 20 25

MAY

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER

DECEMBER

JANUARY

FEBRUARY

MARCH

APRIL

PLANTED

DRAWN CHECKED APPROVED

SCALE 1:5 DATE July 20-1928

of the extensive railroad systems of private ownership. If we take the average family as consisting of five persons, it becomes evident that over 75,000 individuals depend on the sugar estates railroad systems for their livelihood and well being. The average monthly wage of these men for the past two years has been approximately $66.50, this including track repair gangs as well as operating costs.

Now, if this system, about which I have just given you some figures were under a single directing head, it is certain that competent officials would be employed in its management. Accurate and minute figures would be kept of all the details of operation and maintenance. All that modern research and science has discovered to improve efficiency and lower costs would be studiously investigated and adopted as soon as financial and operating conditions warranted. Coal and fuel oil would be subject to proper chemical analyses and purchased only when fulfilling the most rigid specifications. Cars and locomotives would be minutely specified in accordance with the requirements of the service for which they were destined and standards for rails, ties, ballast and materials of every description would be set up and rigidly adhered to.

We have no such single system in Cuba, nor is it probable that any consolidation on so large a scale will ever take place, although the trend is most certainly in that direction, perhaps however, to a more limited degree here in Cuba than in the United States. There are, however, railroad systems of rather substantial proportions, owned and operated by some of the large sugar companies, and expenditures on many of these run yearly to between $50,000 on the fair sized estates to over $750,000 where systems of several mills of the same Company are joined together. Many large economies may still be put into effect on the smaller, as well as larger properties, and I should like to tell you briefly of some that have been made, and likewise of others that may still be made, wherever intelligent thought and study are given to the subject.

Thousands of dollars are spent annually in fuel, wages, lubricants, equipment and track maintenance and I dare say that there are many executives and railroad officials who have never been in a position to state with certainty whether these expenditures have been made with proper regard for economy, based on the service performed in the past and expected in the future. No accounts have been kept of the amount of fuel to make a given run, nor of the number of tons of freight handled by each locomotive from day to day. Engine and train crews are all placed on the same rating, regardless of the fact that some may perform with far greater efficency than others. As long as engines and cars are kept on the track and mill well supplied with cane, everything is considered to be in excellent working order in the Railroad Department. No one knows whether fuel has been burned economically or not, whether lubrication is wasteful, how much more time some train crews employ to cover a given route than others, or whether locomotives are hauling up to 100% of their rated capacity.

In the maintenance of track, cars and locomotives, the same lack of control is evident. Anywheres from $5,000 to $100,000, depending on the size of the estates railroad is being spent for track repairs. How many estates keep proper unit figures of their maintenance cost per kilometer of track, or per ton per kilometer of track? Who can show in actual dollars and cents how much more economical is the upkeep on well ballasted lines over those that have been simply dirt surfaced? How many have seen to it that the ties purchased from year to year have been properly inspected? How many are willing to pay from ten to twenty cents more per tie,

in order to insure an additional tie life of from two to four years? At least 1,000,000 ties are replaced annually in this country on sugar estate railroads and while specifications as to length, width, thickness and kind of wood are generally stipulated, how often is it true that these are overlooked and standards disregarded? Some times standards are far too low to start with; frequently too close a price is bargained for, and again only too often receiving inspectors are, to say the least, careless in their work. In any event, all this results in continued heavy expenditure in track maintenance. Transportation costs, as a consequence, increase, for train speeds must be lowered in the interests of safe operation, and heavier expenditures in fuel and wages are the result thereof.

It is just as essential to know how your money is being spent in the upkeep of cars and locomotives, as it is in operation, and on the maintenance of your track. A number of years ago, one of the largest railroads in the Western part of the United States went into the hands of a Receiver. Amongst other things he discovered what appeared to be rather heavy expenditures in car repairs. When the account had been analyzed and a comparison made with car repair expenditures on other roads where proper accounting methods had been established, it was apparent that here was one of the causes for insolvency. Repairs were costing eleven cents per car mile against an average for well managed roads of from ¾ of a cent to a maximum of two cents at that time. The same state of affairs was found to exist in the Locomotive Repair Department, where large sums had also been expended in a wasteful manner, principally because neither the management or the Superintendent in charge had seen fit to establish a proper accounting system by which they might have regulated their costs and done something to present the solvency of their railroad. The later regulations of the Interstate Commerce Commission have provided for the compulsory adoption of standard accounting systems on all first class railroads in the United States.

The executives and railroad superintendents of sugar estates should know the kilometrage covered by each car and locomotive every day and the total for the month and year. They should know whether cars are costing two cents a kilometer or five cents for repairs and whether locomotives repairs average fifteen or twenty five cents per kilometer of run. With this periodic information when the time comes to purchase new cars or locomotives, the management will be in a positiion to specify that equipment which over a period of years has shown the lowest maintenance costs in proportion to the service performed.

Before closing let me tell you some of the economies which have been put into effect on some of the well managed estate railroads of the Island, after proper operating and cost systems had been installed. The illustrations refer mostly to estates in Camagüey and Oriente provinces though I know of similar good results which have been obtained in other parts of the Island. The examples are not confined to any one mill or group of mills, but have come under my own personal observation at different times during the last ten years. Between 1921 and 1926 the Railroad Department of a large company operating several mills, showed reductions in expenditures from $1,200,000 to $680,000 or over 43% for the period. Still further reductions or economies are anticipated by the Superintendent in charge, and it is confidently expected that by 1930 total expenditures for all items of maintenance and operation will not exceed $500,000. A good part of the saving previously referred to has been effected by lowering track maintenance cost. Money spent in this branch was so well handled, however, that the condition of the line improved from year to year in spite

of the lower outlay in wages and material. Waste and inefficiency were almost wholly eliminated under close and competent inspection. As a result train speeds were increased from 5 kilometers per hour to nearly 12, and gross train loads rose from 800 to an average of nearly 1,200 tons. Telephone dispatching was improved and the movement of trains from point to point greatly expedited. Engine failures were the exception rather than the rule and wrecks which had at first been frequent, are now a rarity. Some new shop equipment was installed and repair costs on cars and locomotives were considerably lowered. In short, the Transportation Department of this Company within a six year period had decreased its expenditures by over $500,000 yearly, because it was taken over by an experienced railroad executive who had initiated a system of control which had enabled him to watch his costs and operating results at all times.

Is it not worth while for sugar estate management to give some thought to the employment of men of the caliber of the one whose work I have just described? It is the part of economy to employ such men and pay them salaries in accordance with the savings which they institute.

On another estate attention was given to increasing the average car load. Fortunately this estate was not subject to the restrictions put into effect by some of the public railroads who insist on creating a restriction with reference to the height at which cane can be loaded. Between 1922 and the end of the 1928 crop, the average car load had increased from 1750 arrobas to over 2300, or slightly over 30%. Fuel consumption was reduced at the same time from eight gallons per kilometer to less than six. In one year alone this Company economized over the previous year something like $40,000 in fuel and $20,000 in Transportation wages, and salaries, an almost equal number of bags being produced each year. No less had been spent on maintenance of track and equipment, but a campaign of education was initiated amongst the engine and train crews and bonuses were paid those men who showed good operating results over definite periods. Time consumed in taking on fuel, water and sand was decreased very materially by certain changes which entailed relatively small expenditure and lubrication expenses were lowered by the installation of mechanical lubricators, and engine failures which had previously occurred frequently, were reduced to only three, the last year of operation.

Locomotive boiler waters had been watched carefully and analyzed from time to time and intelligent attempts made to provide proper treatments to prevent foaming, scaling and corrosion. The yearly cost of repairs in fire boxes, boiler tubes, etc. had been considerable, and still is higher than it should be. Investigations are still being made and many trials of different treatments carried on from time to time, in the hopes that repair costs may be lowered.

These are a few of the important subjects which should be well worth the consideration of every executive and railroad superintendent. No one can afford, particularly in times like the present, to pass up the slightest opportunity to economize in every Department of the industry and on every ocassion and if operating records are kept clear and unit costs studied, expenditures may then not only be justified, but the way opened to better standards of efficiency and decreased costs.

Under the progressive government of General Machado a system of well constructed national highways is now being rapidly pushed to completion. There is abundant food for thought in the possibilities of motor transportation of sugar to the ports whenever the distance is within reasonable economic limits. I look to see a gradual development of this idea in many parts of the Island. I also expect to see

the public railroads of this country establish new methods of handling sugar far more economically than those at present in vogue, to compete with this motor transportation. It is not too much to predict the complete elimination of the jute bag eventually, when public railroads, working with steamship lines operating especially constructed ships will transport our sugars in bulk directly from the factory to the United States refineries without change of cars. Millions of dollars will be economized annually by the elimination of costly and repeated handling charges, and many millions more by the complete abandonment of the use of the well known standard jute sugar bags.

I now take pleasure in introducing Mr. A. Tinoco, who will read the first paper on the program, and to whom, both Mr. Trinler and myself, are most gratefully indebted for the time and labor he has given to the presentation of the subject of Transportation at this meeting.

AUDIT THE TANDEMS

B. P. Luce

In the conventional calculation of sucrose extraction of a tandem we have the sucrose in the cane entering the mills; and account for this, in the process of milling the cane, with the sucrose in the juice expressed by the mills and the sucrose carried away in the bagasse. All things being equal, the greater proportionate part of sucrose carried away or lost in the bagasse, the lower will be our mill sucrose extraction.

It is a local question for each factory to decide what constitutes practical limits to which excessive effort for high mill sucrose extraction should be carried, in view of individual factory conditions, quality and quantity of cane being ground, and point of financial returns. However, until the limit is fixed by the law of diminishing returns, we are all interested in maintaining low sucrose losses in bagasse with correspondingly higher sucrose extraction.

Several very thorough and able papers have been recently published with the view of reducing this current sucrose loss in bagasse. At the last meeting of this society Mr. Scharnberg produced a very worthwhile paper setting forth his experience as well as the results of his calculations for mechanically improving the operation and the extraction of mills. In the recent issue of the Reference Book of the Louisiana Planter, Dr. Van Harreveld, from a different angle, throws more light on this interesting subject of sucrose extraction. His description of the "Noble" patent and the method of approaching this problem in Java is also worthy of deep consideration.

With attention directed to improving our mill work we are in need of directly obtained positive numerical data to substantiate our position. In the average factory our desire to show low sucrose figures in bagasse during the crop, occasions various adjustments to the mills, tightening roll settings, varying of loadings, etc. Sometimes laboratory analyses of bagasse show resulting improvements, and sometimes it does not. These adjustments are generally made from personal experience and observation of the operator. The intention is excellent, but it lacks logic based on a numerical knowledge of the mills.

Under present factory methods the operator is practically in the same position as an engineer trying to adjust the valve settings of a Corliss Engine by watching and listening to the engine's performance, whereas an indicator and cards would supply him with positive data from which he could logically and intelligently correct his valve settings.

Roughly speaking, a tandem using maceration systems has two functions; namely, mechanical actions of crushing and expressing; and, secondly, the leaching action by the application of water, or combinations of water and dilute juices, to the blankets of bagasse. In order to analyze the operation of the tandem, it is essential to have practical reliable data on these functions to logically deduce causes of improper work and correct the conditions.

The following conventional figures taken from the final report of the Sugar Club, covering the work of eighty-four Cuban factories this last crop, furnishes an idea of local mill work, and cane values.

	Average	*LOW Recorded*	*HIGH Recorded*
Total Sucrose in Cane	13.454	11.936	14.995
Sucrose in Juice % Suc. in cane. . . .	93.694	89.60	95.93
Sucrose in Bagasse % Suc. in cane . .	.848	.545	1.38
Bagasse % Sucrose	3.640	5.21	2.78

We know that in actual practice, cane of low fibre content and also cane of high sucrose content permit relatively higher sucrose extractions. That is, with miling conditions in a tandem remaining reasonably constant, higher milling efficiencies will result while grinding fresh mature cane as against grinding stale canne of low purity. In making comparisons of milling efficiencies of one factory with that of another, these conditions should be taken into consideration.

A stricter accounting of our mills, based on figures derived from direct physical weights, and figures from more representative samples, would estalish a positive check on mill work. It is not the purpose of this paper to criticise the accepted conventions of present methods of calculation, for existing conditions now leave practically no other recourse; but rather to call attention to the fact that effort should be directed for more positive numerical data about our mills and their workings.

For example, our present determination of the item of bagasse per cent cane as well as the usual method of securing samples of bagasse, both vitally affecting sucrose extraction, by thus fixing the amount of sucrose in the cane entering the mills and fixing the loss of sucrose in bagasse, are not sufficiently positive. In the one instance we use a calculated figure with no means of checking physically, and in the other instance we do not secure samples of bagasse representative of the entire width of the mill roll, of uniformity, or free from the personal equation.

It is to be hoped that the future will see a practical and accurate bagasse scale as a standard piece of factory equipment installed at the final discharge of each tandem here in Cuba. Also it is to be further hoped that a new standard method will be adopted in which the grab samples of bagasse will be obtained mechanically the full width of the roll, disintegrated to uniformity of size; and by mixing and subdividing it, a representative portion will then be turned over to the laboratory for analysis.

By going one step further and weighting our saturation water with proper factor evaporation, we will have eliminated calculations in our base factors of mill work determination, and replaced customary calculated figures with hard boiled scale weights and polariscope readings. We would then have a positive record on physical weights of material entering the mill; namely, cane plus water, and their combined weight must check within reason with the recorded weight of materials leaving the mill; namely, juice and bagasse. Furthermore, we will be approaching a more positive determination of the item of total sucrose per cent cane based on data from direct

readings. We could then make a daily true audit of our mill work. With daily records of this character we would prove our cane and other weights and audit our tandem operations.

These ideal conditions for checking our mill work may never materialize entirely; yet, effort directed in securing a numerical knowledge of our tandem will furnish a sounder basis for analysing defective operation, and direct our attention to conditions that might otherwise escape our attention.

Confronted with the problem of improving our mill work; again, we need more intimate knowledge of the functioning of the individual mill in the train than that obtained by observation alone. With this in view, at San German, this last crop, certain effort was directed towards securing such information by the practice of determining the densities of maceration liquids and the residual juices of each mill in the tandem.

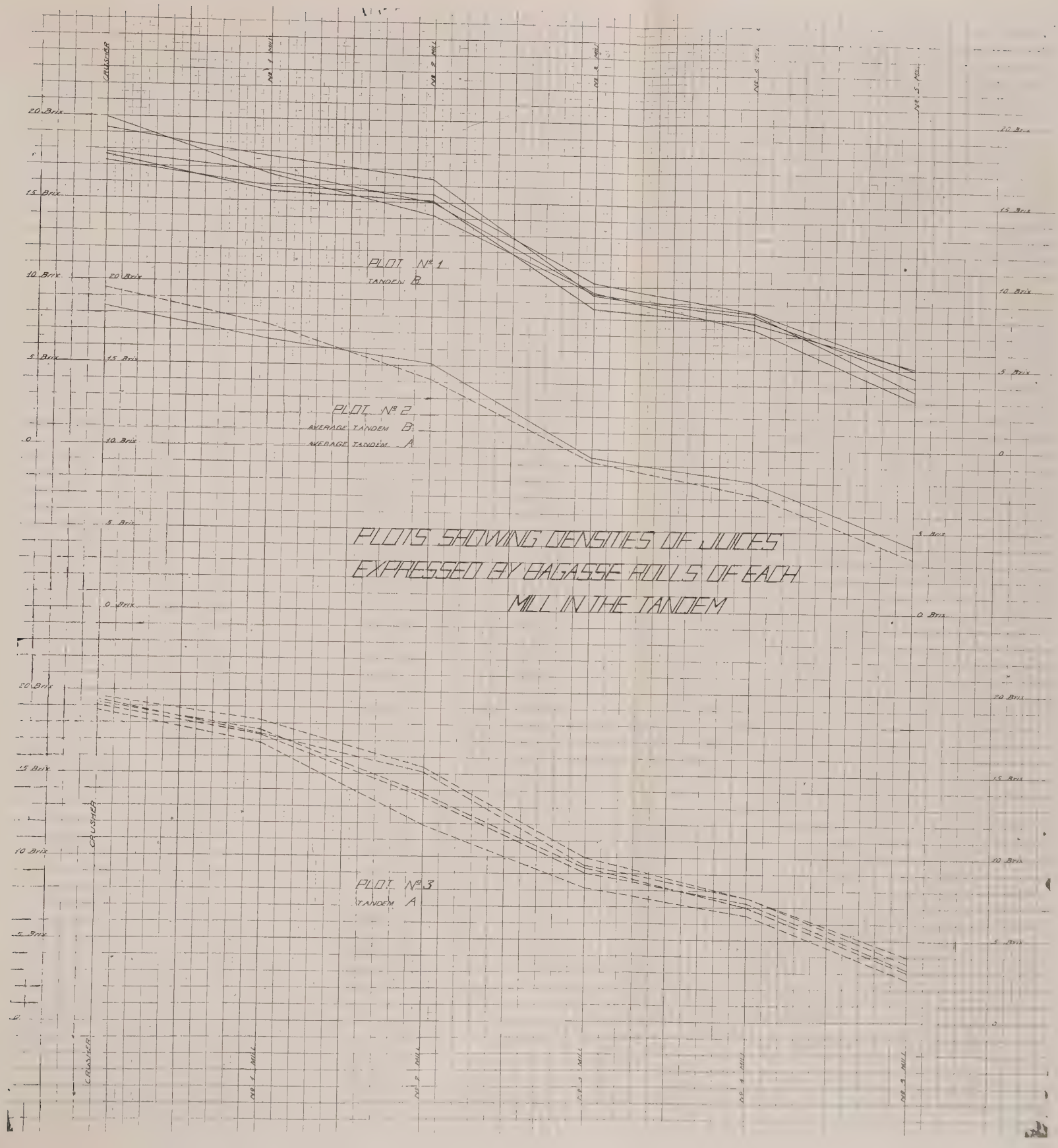
It is assumed, in current milling operation, that the total solids in the juice carried away in the bagasse are of the same proportion as the juices expressed by the bagasse roll. In the tests described below no attempt was made to determine the sucrose content and purity of these juices; it being again assumed, that for all practical purposes, the sucrose in the juices were reduced virtually in the same proporsidered the relative performance of the individual unit mill. The data thus obtained these individual residual juices from one mill to the succeeding one was then considered the relative performance of the individual unit mill. The date thus obtaoned were plotted to scale; the crusher and each mill being the abscissae, and densities or Brixes of residual juices were used as ordinates. Graphs thus prepared immediately showed the "angle of drop" of the juices in the bagasse as the bagasse was passed through each succeeding mill.

The attached sheets show the densities of the residual juices and the densities of the maceration liquids for several consecutive tests, and these data are again shown in the accompanying plot from which certain subsequent observations are based.

An individual test by itself may be open to possible sources of error; yet, if sufficient numbers are taken and incorporated in a series of plots, an average of the results furnishes a practical conception of the relative importance of each mill and the importance of the item of densities of maceration liquids.

Sampling of the juices were secured by grab samples, taken practically simultaneously. Crusher juice samples were taken twice; once as soon as sampling commenced, and again as soon as all samples had been secured. The object of this was to obtain a reasonable assurance that the quality of cane being milled remained unchanged during the collection of samples. In each test these two samples of crusher juices were Brixed first, and if corrected densities were reasonably alike, the balance of samples were cooled, Brixed and their corrected Brixes noted.

For the last crop a series of these tests were run at intervals of several day periods. From this data it was possible to locate weak individual mills or other weak points in the tandem operation, to analyze and to attempt to correct the cause of these conditions. After concentrating on a mill of low efficiency, either by mechanical adjustments or changes in densities of maceration liquid, or both, tests were again run and the results compared with the original plot to see if these faulty conditions had been met. Although these tests were rather sporadic this last season, the possibilities of the information obtainable is considered of sufficient value that this coming crop such tests will become a systematic laboratory routine at this factory.


PLOT Nº 1
TANDEM B
PLOT Nº 2
AVERAGE TANDEM B
AVERAGE TANDEM A
PLOTS SHOWING DENSITIES OF JUICES
EXPRESSED BY BAGASSE ROLLS OF EACH
MILL IN THE TANDEM
PLOT Nº 3
TANDEM A
CRUSHER
CRUSHER
20 Brix
15 Brix
10 Brix
5 Brix
0 Brix

The maceration system employed during these tests was as follows:

(a) Water applied to bagasse entering the fifth mill.

(b) Fifth mill juice mixed with mud from secondary settlers applied to bagasse entering the fourth mill.

(c) Fourth mill juice applied to bagasse entering the third mill.

From the attached graph it will be noted that Figure No. 1 comprises a series of superimposed plots in full line. This is the results obtained from the so-called Tandem "B". Figure No. 3 is a similar series in dotted lines covering data from the Tandem "A", and Figure No. 2 represents a comparative plot of averages of the two tandems.

Upon studying these curves certain conditions are immediately noted, viz:

FIRST: In each tandem the approximate straight line, or directly proportionate drop in Brixes, between crusher and bagasse rolls of No. 2 mill.

SECOND: The sharp drop between Nos. 2 and 3 mills.

THIRD: The flattening out of curve or the less proportionate work of No. 4 mill.

FOURTH: The sharper drop at the 5th mill.

FIRTH: The difference between the operation of No. 2 mill of the individual "A" and "B" tandems.

The first item may be explained by the increasing applied pressure, and that the tandem, up to this point, was expressing unassisted by maceration, the natural juices in the cane.

Conditions noted in observations numbers two to four inclusive, have a logical explanation; due to the ranges in the difference of densities of maceration liquids and residual juices in bagasse.

The writer attaches much importance to the item of densities of maceration liquids and the range of drop between residual juices of the bagasse and the maceration liquids applied to the bagasse.

The fifth observation; namely, the relatively better work of No. 2 mill, tandem "A," as against that of No. 2, tandem "B," was finally analyzed as due to the point of re-introduction of the bagacillo from the strained juices. In the case of tandem "A," this bagacillo was returned in front of No. 1 mill, whereas in tandem "B" it was applied in front of No. 2 mill. With this noted condition of comparatively poorer work by the second mill of tandem "B," as shown by the curves, much attention was directed to attempting to overcome this difference. As a result, readjustements in this mill were made by experimenting with different mill settings, turnplate variations, hydraulic pressures, etc. Slight improvements were noted, but the work of this mill was not materially bettered.

By a further study of these plots, it will be noted that an inefficient performance of any individual mill in the tandem, as exemplified in No. 2 mill, tandem "B," is not compensated for in the work of the remaining mills in the tandem. That is, each mill in the tandem must do its own proportionate work. Poor efficiency at any one station or mill in the cycle of grinding is always reflected in the final bagasse results. This is substantiated by the final bagasse figures for the crop. Tandem "A" bagasse for the crop was 2.68 per cent sucrose, whereas tandem "B" average was 3.59.

It is well at this point to comment a moment on a certain important condition in the straining of the mill juices, aside from the previous deductions regarding point of return of bagacillo to the tandems. This condition is current milling practice;

the movement of the bagacillo is in counter direction to the movement of the blanket of bagasse. In other words, the bagacillo from the weaker juices are washed with richer and richer bagacillo and juices until just before it is delivered back on the tandem, it receives a final bath of crusher and first mill juices, the densest of all. Instead of impoverishing our bagacillo by leaching it we are enriching it, resulting in penalizing the mill in front of which it is discharged.

As a further outcome of these tests and other experiments, approval was granted by our company to install in one of their factories a special maceration handling arrangement. This design consists of the installation of three weak juice non-clogging maceration pumps; one pump for each of the three last mills in the tandem.

So that the unstrained weak juice with its bagacillo will be taken directly from the juice pan of each of these mills and returned to the blanket of bagasse entering the preceeding mill, only the juices expressed by the crusher and first two mills will pass through the conventional trash drag and strainer. The object sought is closer control of compound maceration, the easier impoverishment of bagacillo, making it less of a milling problem; and the straining of the weak juices thru the blanket of bagasse itself, thereby reducing the amount of bagacillo entering the boiling house.

In summarising this article the writer wishes to stress the following main points under consideration, viz:

1. According to present conventions, sucrose extraction and sucrose in cane are calculated figures. More positive data, substantiated by actual weights, are required before we can check our mill work completely.
2. Stale cane is a detriment to high sucrose extraction.
3. Fibre content of cane has its influence in sucrose extraction.
4. In comparing the tandem work of one factory with that of another, certain consideration should be given to the quality of cane ground.
5. More representative bagasse samples are necessary as a truer criterion of mill work.
6. Lacking the means now of obtaining actual weights of materials handled, still much can be done towards analyzing the mill work.
7. Series of tests of densities of residual juices of the individual mills disclose the importance of the following, in respect to sucrose extraction:
   (a) Densities of maceration liquids.
   (b) The influence of point of introduction of bagacillo to the tandem.
   (c) Influence of defective work of an individual mill on the tandem as a whole.
   (d) Besides these conclusions, further experimentations and study of residual juices opens up the opportunity of knowing better our individual mills and diagnosing accurately their troubles.

Although the day of bagasse scale installation may be remote and a positive audit of the mills impractical now; yet, by directing our attention, more as accountants, and no less as engineers, to our mill operation, will we improve our extraction.

TANDEM "B"

Crusher First Sample	Crusher Last Sample	Residual Juice 1st Mill	Residual Juice 2nd. Mill	Residual Juice 3rd. Mill	Residual Juice 4th Mill	Residual Juice 5th Mill	2nd Juice Applied to Bagasse Entering 1st and 2nd Mills	4th Mill Juice Applied to Bagasse Entering 3rd Mill	5th Mill Juice & 2nd Mud Applied to Bagasse Entering 4th. Mill
17.65	17.80	15.60	15.10	8.6	7.8	5.1	11.30	5.7	4.9
17.30	17.40	15.90	15.50	10.2	8.5	5.0	10.30	7.3	6.6
19.30	19.00	17.70	16.40	9.4	8.2	4.5	11.00	6.9	6.1
19.90	19.70	16.60	14.20	9.5	8.4	3.7	11.70	6.9	5.6
17.80	17.80	16.80	15.00	9.6	7.4	3.1	11.00	6.8	5.5

TANDEM "A"

19.6	19.4	18.2	15.4	10.0	7.6	3.7	10.9	7.4	5.7
19.4	19.7	17.4	15.1	9.5	7.6	4.0	11.3	6.9	5.6
18.6	18.8	16.8	11.9	8.1	6.5	2.6	11.2	6.1	5.6
19.1	19.0	16.3	13.6	9.0	7.0	3.1	11.4	6.6	5.4
19.3	19.4	17.6	13.8	9.4	7.2	3.3	10.8	6.5	5.2

AVERAGE TANDEM B

18.38	18.34	16.52	15.24	9.46	8.06	4.28	11.06	6.72	5.58

AVERAGE TANDEM A

19.2	19.26	17.26	13.96	9.2	7.18	3.34	11.12	6.7	5.5

CHANGES ON Mr. H. J. B. SCHARNBERG'S ARTICLE

FROM LAST PARAGRAPH ON SECOND PAGE OF TEST TABLE No. 4 (FOLLOWING PAGE 101 OF TEXT) TO END OF FIRST PARAGRAPH OR NOTE ON FOURTH PAGE OF TEST TABLE No. 4, TEXT SHOULD READ AS FOLLOWS:

After a pressure of 3680 lbs. pr. sq. in. had been on the cap, which was fitted with the fiber disk, the starting pressure went up to 4100 lbs. per sq. in. This was either due to the surface between fiber and bushing becoming dry, or due to the expansion of the fiber, or both. The pressure difference is bound to be greater, when the fiber disk becomes moist, as it will expand, and thus become wedged in the cylinder. The coefficient of expansion of fiber is about 40.33%. A red fiber disk was submerged in water for 12 hours, and after removing the following changes had taken place. "The thickness had increased from 1" to 1" and 286/1000", and the diameter from 14" to 14.625" so that the original volume of 159.94 cub. in. had increased to 216.035 cub. in.

TEST No. 3

No changes were made in the bottom cap, conditions remained the same as in test No. 1 and 2.

Static pressure on bottom cap	3530.00	lbs. pr. in.
Starting pressure	3600.00	lbs. pr. in.
Moving pressure	3550.00	lbs. pr. in.

Top cap was fitted with a special Monel Metal ring, for protecting the heel of the leather. The same leather was used in this test, as in No. 1 and 2.

Starting pressure on top cap	3680.00	lbs. pr. in.
Moving pressure	3630.00	lbs. pr. in.
Total area of friction surface of packing	87.96	sq. in.
Total pressure on friction surface of packing	319,294.8	lbs.
Hydraulic pressure required to overcome friction	12,315.2	„
Plus weight of 2 rams	508.0	„
Total pressure required to overcome friction	12,823.2	„
Presure required to overcome friction in bottom cap, as in as in test No. 1, and 2	7,951.0	„
Pressure required in top cap, fitted with the 1" leather and Monel Metal ring	4,872.0	„
Considering the moving pressure in the top cap as the static pressure, there would then be on the top roll, while grinding cane, a pressure of	1,117,604.4	„
which is equal to	558.8	tons.
If the top roll rises, while grinding cane, the friction pressure would have to be added to this, which would be 9744.4 lbs. if both top caps were fitted with 1" leathers, and Monel Metal protective rings, which pressure equals	4.87	„
and when the roll rides back to normal position, this amount will have to be deducted from the static pressure, so that for each cycle of roll movement we would have a difference of 19,488.8 lbs., which is equal to	9.74	„

and instead of having 558.8 tons. of pressure on the fiber and roll in the upward movement, we would have 563.67 tons.
and on the downward move we would have . . . . . 553.93 „

THE COEFFICIENT OF FRICTION OF THE MATERIAL USED IN THE TEST IS AS FOLLOWS.

TEXT, FROM LAST PARAGRAPH OF PAGE 101 TO END OF FIRST PARAGRAPH ON PAGE 102 SHOULD READ AS FOLLOWS:

Ordinary 1″ high cup leather, with fiber disk underneath.	0.0587
With 1″ leather only, no fillet on edge of ram	0.0488
With 1″ leather and Monel Metal protective ring	0.0300
With ¾″ leather and Monel Metal protective ring.	0.0278

If the friction surfaces become dry, this value will be much greater.

As we are aiming to reduce the deflection in the roll shaft as much as possible, we should avoid using a packing material in the hydraulics, which would result in extra shaft stresses, and which in the test we found to set up a greater pressure difference for each cycle of roll movement. Being of intermittent value, these extra stresses imposed upon the shaft are comparable to the blows of an Impact Testing Machine, not to the same degree of intensity, but are very harmful to the efficient operation of the mill, and have a fatiguing effect on the equipment. In making analysis of bagasse or juice samples taken from the different mills in a tandem, we often show results, which we know to be not true. Likewise in the case of bagasse analysis for final moisture content. After we have increased the hydraulic pressure on the last mill, we find the per cent of moisture heigher, then with less pressure, the data obtained often runs so wild, that it is of no value. All this can only be attributed to the greater pressure difference for each cycle of roll movement, brought about by the increased pressure on the rams and the resultant greater friction values.

To the accumlator rod packing we should pay as much attention, as to the hydraulic ram packing. The rods should not become abraded, where the packing leathers are installed, and they should be of uniform diameter. Should the surface become rough and cut, as it often does, and should the packing leather become wedged between rod and follower plate, a total friction resistance of 300 lbs. could easily exist at this point, and with a 2½″ diameter accumulator rod an extra pressure of 18780 lbs. would be put on the two 14″ rams.

In the test we show an average of 20 lbs. pr. sq. in greater pressure in the bottom cap. when the ram was moving, then what the static pressure was. This means, that we had a friction value of 159.6 lbs. total on the accumulator rod, which in turn put an extra pressure 3078.0 lbs on the two 14″ rams. The reason for the friction value in this case being so low, was because the rod and packing was fitted with special machined protective rings, like in the case of the ram packing.

Another very important point in connection with the hydraulics on the mills, and the accumulators is the size of pipe used in connecting these together. In my experiences I have found, where the Mill Engineer reduced the connection by installing a steel nipple with only a ¼″ hole drilled in same. The reason given was that the accumulator moved too freely, and by reducing the pipe connection this trouble was partly cured. This is a very dangerous procedure, as it retards the roll movement, and should abnormal condition in milling be brought about, either on account of the clutch on the intermediate carrier becoming loose momentarily causing a pile of

ground cane to be heaped up on the carrier, and then fed to the mill, or by passing a piece of iron to the mill with the cane, we might break the rolls, or housing.

Very often we find the key's in the mill king bolts, located under the mill sole plates partly sheared in to, this is not on account of tightning the cap nuts too much, but on account of sluggish, or jammed hydraulic rams, and in some cases due to too smaller pipe connection to the accumulator. As a rule these connection are of the proper size, when a mill is originally installed, but later on, when some changes are made in the milling plant, in some cases very little attention is being given to the pipe sizes, when reconnecting the accumulator, and whatever there happens to be on hand in the line of pipe connection, it is used, whether it is of the proper size, or not.

The pipes connecting the hydraulic to the accumulator should not be less than 1″ size for 14″ rams, and where the accumulator is located over 100-ft. distance from the hydraulics, the pipes should be of 1 ¼″ size. Pipes of this size will prevent any great pressure difference between hydraulic cap, and accumulator, should the top roll rise abnormally due to a piece of iron or other solid matter passing through with the cane.

———————:x:———————

THE NEW SALINAS – TAUPIER PROCESS FOR THE TREATMENT OF CACHAZAS WITH TOTAL SUPPRESSION OF FILTER – PRESSES

Juan G. Salinas

The Process to be described has originated in Cuban sugar mills in actual crop working conditions and is intended to eliminate the filter-press station with a minimum of new capital investment and a maximum recovery of sucrose.

We believe it redundant to dwell upon the multiple technical and financial advantages which the suppression of the filter-press station implies in raw sugar manufacture as apart from all that has been said upon the matter it is a fact, well rooted in the minds of all sugar men, that cachaza, with suitably modified physical structure, can be easily incorporated in the bagasse mat during milling, thus using it as fuel and that, on the other hand, the suppressing from the manufacturing equipment of a department so relatively costly as the filter-press can and does introduce remarkable economies in the general fabrication cost and this is, in the last analysis, the end sought, or that should be sought, in every industrial undertaking.

From he initial experiments carried out by Thomas and Petree in Australian sugar houses, engineers, chemists and sugar producers in all cane countries have been expectantly awaiting the final results to be obtained and have already had, in fact, ample opportunity to corroborate its commercial success, which confirms the feasibility of manufacturing *high grade raws* at the plantation without the use of filter-presses. It should be noted that this goal had been striven for, although without practical success, by American, French and Dutch experimenters respectively in Louisiana and Hawaii, Egypt, Mauritius and Reunion and in Java.

It is therefore an unchallenged fact that the sugar industry is endebted for this first step in the simplification of the manufacturing process to the intelligent tenacity and the experiments of Thomas and Petree and, subsequently, to the machanical perfection of Dorr and Gilchrist clarifiers.

UNDERLYING PRINCIPLES

Technically the entire problem may be said to have revolved around two facts, fundamentally opposed, to wit:

Firstly, the extraordinary filtering properties of bagasse; secondly, the complicated physico-chemical structure of cachaza.

The first fact has led many chemists and sugar engineers, at different times and in different countries, to make use of bagasse as a filtering agent for the cachaza originating in the process of defecation of the juices, but all experimenters, at every place and date, have been balked by the said physico-chemical nature of cachaza. Therefore, *to change or modify the physico-chemical nature or state of cachaza* has had to be the starting point of experiment in order to overcome what is, undoubtedly, the major difficulty in its application to the bagasse blanket.

In this direction it is evident that Thomas and Petree have obtained frank sucess, "stabilizing" cachaza through double defecation, i. e., separate defecation of the juices issuing from the first and last mill, or, to express the same thing in a different manner, increasing the filtrating properties of cachaza to thus facilitate its application to and absorption by the bagasse during the milling cycle.

PRINCIPLES OF NEW SALINAS-TAUPIER PROCESS

Incorporation of Cachaza.—Considered physico-chemically the new process has as a basis the same purpose of increasing the filtering index of cachaza. We have procured and obtained its more perfect incorporation, that is, to give it a granular structure by the grouping of colloidal and other elements in suspension through the addition, at certain stages of the process, of a quantity of Filter-Cel or diatomaceous silica and of the necessary dosis of milk of lime in order to bring about the formation of a mono-or bicalcic saccharate in the mass of the final cachaza which is thus notably incorporated, or efficiently prepared for its filtration through a bagasse blanket of ordinary thickness.

The experience in the formation of the diverse compounds of sucrose and calcium which has been gained in practice with the systems of single and double carbonatation used, principally, in the manufacture of white sugars, teaches us under what circumstances the degree of temperature rise excersises and inerting action on slightly or heavily alcalized cane juices, and thus it is that we have been able to circumvent, in our process, all the inconvenients and risks attendant upon the formation of calcium saccharates, succeeding, on the other hand, in destroying the action of other organic salts of calcium the melassigenic influence whereof gives rise to very considerable losses in fabrication.

Initial Alcalization. On the other hand, with our process, we realise the prior partial liming of the juice in the course of its expression by the mills, that is, by discharging the cachaza, already incorporated by a basis of calcium saccharate, in a sufficiently dilute condition as imbibition on the bagasse mat at the delivery side of the first or second mill, the acid juice still contained in said bagasse is partially neutralized by the excess of lime contained in the incorporated cachaza macerated, which results in a manifest advantage from the standpoint of the preservation of the juices, the purity whereof remaine unaffected, as we have been able to ascertain from numerous tests.

Below we offer data obtained in actual practice and which will throw much light on the inverting action of the acids of the juice immediately after extraction of the latter by the mills:

	With Initial Liming by means of Incorporated Cachaza	By the Current System of Liming on Mixed Dilute Juices
1st. Test (Average 24 hours)		
1st. Mill Juice Purity	86.45	86.15
Mixed Dilute Juice Purity	83.85	82.05
Difference	2.59	4.10
2nd. Test (Average 48 hours)		
1st. Mill Juice Purity	84.50	85.10
Mixed Dilute Juice Purity	82.95	82.35
Difference	1.55	2.75

Continuing these observations we have noted a market improvement in the purity of defecated juices in favor of the system of initial liming, which allows us to definitely establish the advisability of liming the juices immediately upon expression by the mills, thus avoiding the manifestly destructive action of the acids on the sucrose, and the bacteriologic action of the ferments which, favored by the medium, develop in the canals, gutters and receiving tanks located under the drags.

Easiness of Milling.—Finally, and despite the success obtained with our process of incorporation of the cachaza through the use of calcium saccharate and diatomaceous silica or Filter-Cel, we have advantageously complemented the operation with the use of the Taupier Eliminator, or pre-separator, in order to obtain a higher milling efficiency and to radically prevent and eliminate the always damaging risks of choking, due to the slip caused by cachaza. The elemental function of the Taupier Eliminator is the separation from the previously incorporated and fluid cachaza of all gummy foams and other gelatinous and glutinous substances still in suspension and which usually obstruct the efficient working of the mills, such damaging substances being trapped and retained in the bagasse mat contained in the Eliminator.

Consistent with out extensive observations of the systems at present in use and of others under private test, we have the firm conviction that the application of cachaza on the bagasse at the mills requires that the applied mud be given the physical structure that we have succeeded in giving it with our process of incorporation, as it is a fact that the necessity of maintaining a normal milling rate forces the factories which employ the system of applying the muds to the bagasse to modify, with some detriment to efficiency, the entrances or feed apertures of the rolls, thus bring about a not inconsiderable drop in the efficiency of the work and the sucrose extraction.

Once the cycle of filtration of cachaza has been completed through the Taupier Eliminator, the bagasse which has served as a prior filtering medium and the foams trapped therein are discharged directly through suitable continuous means which distribute them on the bagasse mat or else together with the material separated by the juice drag of the first mills.

With our Eliminator we have succeeded in stabilizing the milling with the maximum of efficiency without having registered, during the entire crop, the slightest inconvenience from shut-downs or stops due to congestion of bagasse at the mill entrances, which is the most important and most serious drawback in the practice of applying cachaza.

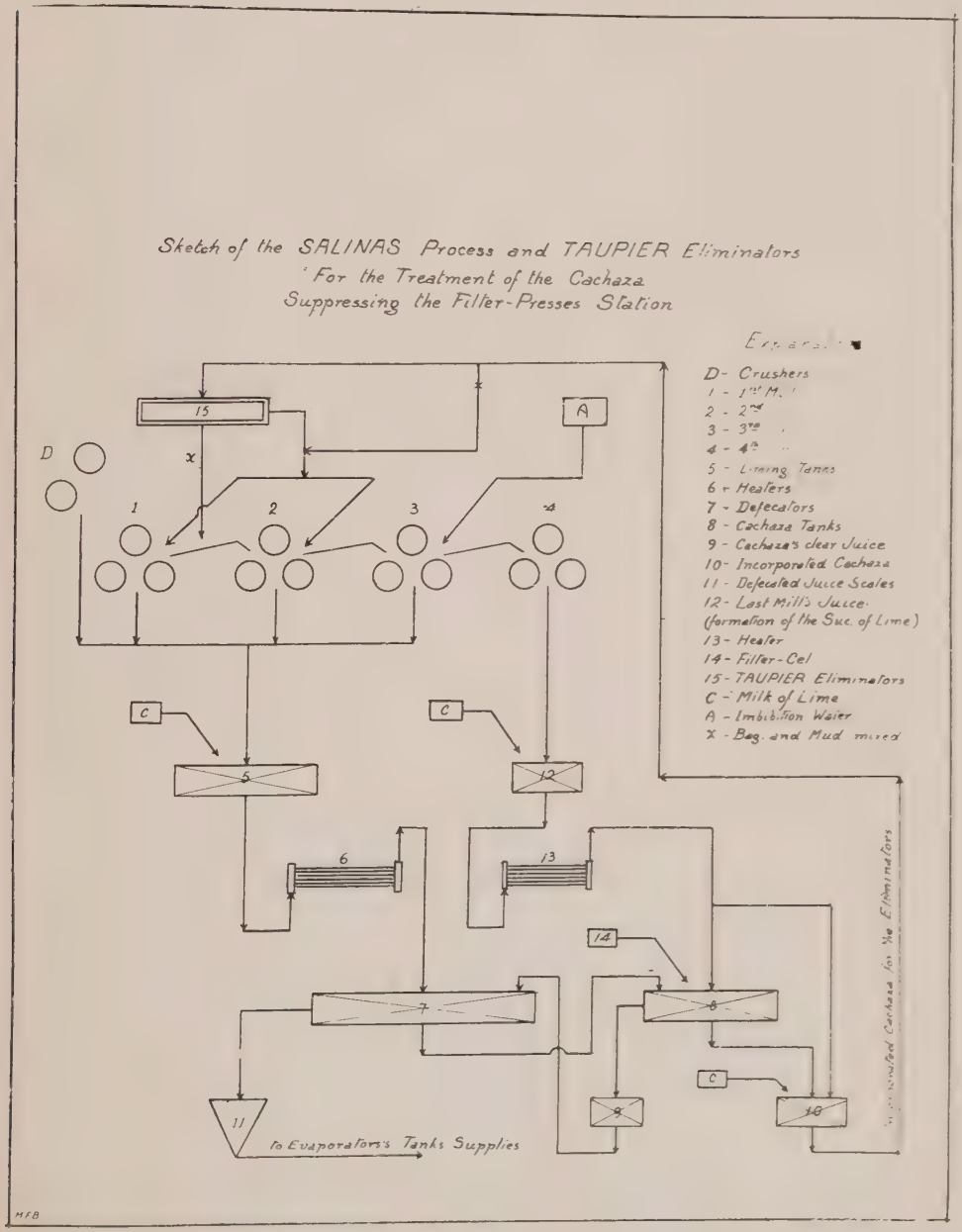
Method of Operation of the Salinas-Taupier Process.

As shown by the accompanying diagram the process comprises two distinct phases, perfectly complementary, to wit:

1st: Physico-chemical treatment or incorporation of cachaza; and

2nd: Mechanical treatment or separation of slippery substances.

The process may be put into operation with equal success no matter whether the factory is equipped with the current type of defecators, or with Dorr or Gilchrist clarifiers or with any type of cachaceras.



Juices from first mills are treated by liming, heating and defecation, as usual and the cachaza obtained is sent to the cachaceras, also in the usual manner. The juices

from the last mill or mills are submitted, cold, to the special treatment with milk of lime, are heated to a specified temperature and discharged into the cachaceras mixing them with the cachaza proceeding from the defecation and adding thereto a certain proportion of Filter-Cell or diatomaceous silica, according to the constitution of the juices treated. Cachacera clear juices are added to those issuing from the defecation and the resulting heavy muds again treated with milk of lime to form a mono—or bivalent calcium saccharate, with due mechanical agitation, hence being sent to the Eliminators near to the mills.

We append two views of a typical installation showing the position of the Eliminators with respect to the train of mills.

The characteristics of the process as a whole consist in the exclusive suppression of the filter-press station, utilizing the existing equipment of defecators and cachaceras, generally very good in all Cuban mills, and adding only a convenient battery of Taupier Eliminators, that is, *obtaining the highest efficiency* and the *maximum economies* with the *least capital investment.*

ADVANTAGES BOTH THEORETICAL AND PRACTICAL OF THE SALINAS–TAUPIER PROCESS

1.—Prevention of the usual fermentations at the mills and unaltered conservation of the purity of the juices;
2.—Conservation of the material of the intermediate carriers, since they are not in contact with acid juices, which are now limed in the bagasse blanket itself;
3.—More uniform defecation and easiness of maintining a constant pH factor of defecated juices;
4.—Initial elimination of micro-organism through the influence of pre-alcalization;
5.—Diminution of the colloidal coefficient of the juices and the index of viscosity of the syrups;
6.—Easier filtration of the incorporated cachaza after having passed through the Taupier Eliminator, where all substances producing or tending to produce slipping of rolls are retained;
7.—Higher milling efficiency by suppression of the causes of choking and slipping;
8.—Utilization of cachaza as fuel, with manifest advantages for the practical cleaning of the furnaces, as with the calcium saccharate process ashes produced are more easily desintegrated and more friable, favored by the calcium silicate formed during combustion;
9.—Suppression of infections in the filter-press department, which are notably detrimental to the quality of sugar produced.
10.—Superior quality of sugars obtained in the standard process of fabrication, both from the point of view of their physico-chemical structure as from the more important one still of their bacteriological coefficient, which determines their capacity of conservation after sacking.

ECONOMIC ADVANTAGES OF THE SALINAS–TAUPIER PROCESS

1.—Only the filter-press station is suppressed, that is, the most costly, relatively, of all the fabrication equipment;
2.—Defecating equipment and cachaceras are kept in practical and more effec-

tive use. This equipment, if scrapped, would have little value as a saleable item and represents a certain percentage of the capitalization of the mill.

3.—Cachaza is used as fuel which, conservatively estimated, represents about 5% of the total used in the factory that is, more or less about $50.00 for each 100,000 arrobas of cane ground.

4.—Items of repair, operation, cloths, gaskets, etc., of the filter-press station are saved, they representing about $60.00 per annum for every 100.000 arrobas of cane ground.

5.—As an average, taking into consideration the diversity of conditions encountered in different Cuban factories, particularly with respect to the production capacity, the economy of this new process represents each year from $750.00 to $1,500.00 for every 1,000,000 arrobas of cane ground, according to whether the capacity of the mill is less or more than 200,000 bags and, on the other hand, the installation cost would be approximately, *and for once only,* from $750.00 to $1,500.00 in the same capacity relation, that is to say, the investment effected pays for itself practically during the first year of operation.

Conclusion

The technical progresses which the present financial condition of the Sugar Industry shows it advisable to put into practice are those which have taken into consideration the cost of investment and upkeep, so as to obtain *with the smallest investment the greatest efficiency and the greatest economy.*

THE QUESTION OF PURCHASING CANE BY ITS ANALYSIS AND THE ADVISABILITY OF FIELD YIELD CONTROL

E. E. Domínguez

Several sugar House Laboratory procedures aiming to explain the advisability and practicability of purchasing cane by its analysis have been evolved by sugar chemists investigators in the various sugar producing countries of the world. It will be needless to add herein a bibliographic list of such works, and suffice to say that we have seen a pretty thorough review of cane analysis procedures ably presented by Mr. J. G. Salinas at the first meeting of this Society.

We think with pride of the magnitude and the geographic key position of the sugar industry of Cuba. It being like any other commercial industry subject to the unavoidable law of supply and demand, we now find it at the low ebb side of such law. This grave crisis compels executives, managers, and sugar technicians alike to do reflective thinking, to spare no small or large efforth, and it should be our agreeable pleasure to cooperate with our contributions on any of the multitudinous details that make mill management and sugar production profitable.

The question of cane purchase by its analysis and the possibility of making it an institution in the Cuban sugar industry has been already through out, as regards Laboratory technique and arithmetical formulas, by Mr. J. G. Salinas in his "Salinas" formula, and by the Honorable Rafael Sánchez Abulí in his method of "Proportional Value."

As is well known, plans or measures affecting public interests cannot at once be adopted, neither could they become at once effective until their advantages and benefits and their practical adaptability is thoroughly established. A sudden change into a new system of business relations between the cane planters (Spanish, colonos)

and the mill owners (Spanish, Hacendados) will naturally result into numerous difficulties, some of legal nature, and others of just plain human understanding. Therefore, the institution of a plan of far reaching consequences needs the careful study and intelligent discussion of the members of this Association.

Let us first consider our preparation on technical Laboratory means to gauge and account for the various physical components of the cane immediately after it is crushed. If we pause sufficient time to examine the various formulae submitted we find that they are more or less involved, and that several purely theoretical factors enter into their make up that render the system subject to proportional adjustments and corrections of technical nature in order to balance with the sugar actually bagged. For, it will be easy for anyone to see that theoretical or even average factory results of a number of years or of a previous crop cannot be duplicated at any time in the following crop. These formulae are not readily understood by the average sugar chemist, still less by the mill management, and it would be utterly foolish to expect the cane planter to understand any part of it. First of all, factory extraction figures are indispensable for the correct statement of how rich or how poor a cane is in the hundreds of carload lots belonging to the numerous cane planters. In the event of cane purchase by its analysis, it is of paramount importance to know the actual weights of the main constituents of the cane after its disintegration and of any foreign material introduced in the process of crushing. This means that a positive system of mill control is required in order to ascertain, beyond doubt, the two essential figures, Mill Extraction and Boiling House Extraction. The knowledge of weighed quantities on cane, maceration water, bagasse, raw juice, sugar, and waste or final molasses would result in a system affording protection not only to the mill owner but also to the cane planter in the event of legal or doubtful contentions. At the present time, practically 100% of the mills require weighed quantities on cane, raw juice, and sugar; some of the more progressive also weigh their waste or final molasses, but there ave very few instances, if any, where the maceration water and the bagasse are weighed. The institution of a positive method does not require any large outlay of money and it is of simple application. The Laboratory procedure and accounting of such system is fully explained in the paper "A Method to Determine Directly the Analysis of Cane and Normal Cane Juice Omitting the Milling Factor" presented by the writer at the first meeting of this Association.

Another figure that bears intimate relation to a positive method of Mill control, and which cannot be overlooked, is the careful calculation of the Java Ratio. The Java Ratio enables the control man to state correctly the percent sucrose in the cane found in the various carload lots of cane of different ownership. It is absolutely important, then, to obtain the correct average analysis of the Crusher juice extracted from each carload. To do this the weight of the juice extracted by the first crusher and the solids and sucrose therein must be accounted for and properly recorded for each carload of cane ground. The Java Ratio is simply the division of:

$$\frac{\%\ \text{Sucrose in the cane}}{\%\ \text{Sucrose in Crusher juice}}$$

The juice extracted by the first Crusher is never weighed and it would be hardly economical to attempt to weigh it. Its weight, however, may be determined, close enough for purposes of averaging, from expressed Purities. The formula may be stated as follows:

$$X = p - \left(\frac{P - p}{P - p'}\right) = 100.$$

where,

p = Total expressed Purity (Purity of the mixed juice).

P = Initial expressed Purity (Purity of the juice from first Crusher)

p′ = Final non-expressed Purity (Purity of the Residual juice).

X = Juice extraction done by the first Crusher. This figure varies from 37% to 66%, it all depending on close or open setting for heavy or light initial duty thrown on the first Crusher, and on the type of maceration arrangement applied on the subsequent mill units. The calculation must be made separately for each tandem in mills of two or three tandems. The weight of cane of each carload multiplied by the percentage found gives the weight of the juice extracted by the first Crusher. This is repeated for each car ground during the day. The terms p, P, p′ are daily obtained from the data book of the Mill Laboratory. The weight of the juice extracted by the first Crusher multiplied by the corresponding percentages of solids and sucrose gives the weights of these constituents to obtain the correct average analysis of Crusher juice in the lots of cane of different ownership during the period to be liquidated.

Under the conditions of a positive system of Mill control the yield formula to be employed differs from other suggested formulae in that its components are percentages derived from actual weighed quantities, the use of factors and theoretical figures being omitted. The formula is as follows:

$$X = \frac{s \times J \times E \times R}{P \times 100} \times 100$$

Where,

s = Sucrose of juice from first Crusher. This is the average percent corresponding to the lot of cane in question during the period to be liquidated. This figure is obtained from the individual data sheet containing the carload analysis accounting.

J = Java Ratio. This is the average percent during the period to be liquidated. It is obtained from the data book of the Factory Laboratory. It is a constant figure for the various lots of cane of different ownership ground during the period to be liquidated.

E = Sucrose Extraction. (Mill Extraction). This is the average percent during the period to be liquidated. Otherwise the same as specified under Java Ratio.

R = Recovery of sucrose % sucrose in juice. (Boiling House Extraction). Actual figures obtained in the measurement of sugar in stock and average figure on Purity of final or waste molasses actually made, during the period to be liquidated, are to be used. The S–J–M formula should be employed for the checking of sugar estimated in process. Otherwise the same as specified under Java Ratio.

P = 96. This is the polarization uniformly adopted as Standard for the commercial raw sugar produced in Cuba. Hence, the commercial or Factory yield is reduced to basis of this Standard. Therefore, this is a constant figure.

X = % yield in 96 degree sugar. This percent corresponds to the lot of cane in question during the period to be liquidated.

An example of the use of the S–J–M formula will be herein illustrated in order to show the manner in which under-estimations or over-estimations of sugar in process may be avoided, as well as incorrect statements of the Factory yield. Let us suppose, for a moment, that a liquidation period is now terminated and that R in the above formula equal 91.95%, and that X equals 10.81 %. Employing the corresponding average percentages obtained by the Mill Laboratory during the period, the check formula is applied as follows:

$$X = \frac{S\ (J - M)}{J\ (S - M)} \times 100.$$

Where,

S = Purity of Sugar = 97.

J = Purity of mixed juice = 81.81.

M = Purity of final molasses = 29.74. Solving for X we have,

X = 91.79%.

It is found that there is a difference of 0.16% in the value of R, showing that either the quantity of material in process has been overestimated, or the analysis of the final molasses expected from such material is slightly low. Hence, the Factory yield of 10.81 is slightly too high, and careful stock-taking is necessary.

The field data and the carload analysis method, in connection with the above system will now be briefly described. For the field man the method or plan begins with the notation, on the carload card, of the field number, name of cane plantation (Spanish, colonia), name of cane planter, field scale weight, and date when cane was cut. This information goes directly to the statistician in charge of cane classification by field number, cane plantation, and cane planter ownership. For the chemist the method begins with the taking of the car number at the moment it is being emptied on the cane conveyor. The passing of the cane by the conveyor through the first Crusher is conveniently spotted or flagged, so that a continuous first Crusher juice sample is secured from it, the procedure being repeated for every car. The analyzing chemist is not given any information as to the ownership of the carload of cane, shipping point, etc. His business is to see that the sample is taken correctly, to analyze immediately the juice, and to enter, in a special data sheet furnished, the results on Brix, sucrose, and the Purity of the juice from each carload of cane. Brix is determined by the direct spindle method, sucrose being determined by dry lead subacetate method. At the end of 24 hours the filled data sheet is immediaely sent to the classifying statistician who credits the cane planter, in his individual accounting sheet, with the weights of crusher juice, crushed juice solids, and crusher juce sucrose corresponding to each and every one of his carloads of cane that were ground during the 24 hours. This operation is repeated at the end of every 24 hours till the end of the period to be liquidated, and so on till the end of the crop. The percentage of sucrose in the cane is recorded daily in the same manner. The calculation is made employing the Java Ratio, thus:

$$X = \frac{S \times J}{100}$$

Where,

s = Sucrose of Crusher juice. Average daily percent corresponding to cars

analyzed during the day, cars being classified by field number and name of cane planter.

J = Java Ratio. Daily percent, as per official daily Report of the Mill Laboratory.

X = % Sucrose in the cane corresponding to cars analyzed during the day and corresponding to a determined field No. and to cane planter So and So.

It will be found that this figure is more conveniently determined at the end of the period to be liquidated, instead of figuring it daily.

Finally,. attention is again called to the realization of what the institution of cane purchase by its analysis means. It requires careful and accurate determination of quantities, hence a positive method of Mill control is the logical and indicated procedure. Actual calculation of sugar yields and yield liquidations should preferably be made in periods of not less than fifteen days duration, or a multiple thereof, and in some cases at the and of the crop. The reason of suggesting a minimum of fifteen days period is that, in actual practice of factory operation, final molasses are not actually produced before the sixth or seventh day of grinding operation, and yield calculations where final molasses Purity would be assumed should not be allowed. Assumed final molasses Purities are allowed only on a small amount of sugar, as for example, at the time of stock-taking for the purpose of determining the quantity of sugar in process at the time when the period to be liquidated is to be determined. Further, in districts of numerous small cane planters a proportionate system of harvesting should prevail as a fair and equitable system.

We now have seen the direct procedure whereby the sugars belonging to the mill owners and the cane planters may be properly accounted for under the conditions of the direct system of Mill control and mill yield determinations. Retrospectively thinking as to the actual possibilities of making a move towards purchasing cane on basis of its analysis, a better grasp of the situation may be had by establishing a general comparison of the modus operandi of the present system and the one proposed.

General consideration of the modus operandi of the present system of purchasing cane by its weight: Cane culture in Cuba is extensive. The Standard variety is the Cristalina cane which thrives well under the natural conditions of rainfall. It mills well, as its fiber content is not very high, ranging from 10.50% to 10.75%. The general average yield for the Island, during grinding operations, develops the following trend: second half of December, 9.0—9.5%; January, 10.0—10.5%; February, 11.0—11.5%; March, 12.0—12.5%; April, 13.0—13.5%; and the first half of the month of May, 13.5—13.75%, after which date yields commence to decline rapidly usually due to the setting in of the rainy season. This gives a general average yield of 11.9% to 12.2% quite safely and may be taken as the basic yield of Cuba. Cane is paid by weight, the cane planter receiving, as an average for the Island, 5.75 to 6.25 arrobas (1 arroba equals 25 ponds) sugar per 100 arrobas cane delivered to the Mill. The problem of the cane planter in his cane liquidations is very simple, since all he has to do is to keep track of so many arrobas cane delivered to the mill and so many arrobas sugar he will get back. The arrobas of sugar at so many cents per pound, according to the promedio (average market price) will give him so many dollars and cents. He does not have to worry on the YIELD now and the YIELD then; he wants large weight in cane no matter whether it is rich or poor in sucrose content. Trash, dirt, young cane shoots, deed stalks, green points, sour burnt cane, all

count in his favor, since all of these materials constitute added weight. On the other land, the mill management figures out that when grinding operations start in December, which is the normal rule, it will have to stand an operating loss at the beginning, but calculates to make up such loss by the higher yields obtained later in the season. This is not scientific to be sure; however, 99.99% of the mills in Cuba do it and no financial disasters have been registered due to adherence to the rule of paying cane by weight. The cane planter liquidates every fortnight if he wishes, and everybody seems happy, at least as long as the market prices are maintained within a limit of reasonable economic returns. The facility of the modus operandi of this system is one of its great advantages. However, viewing it from the standpoint of scientific management, certain disadvantages are evident; for example, the mill management can hardly hope to get superior and cleaner cane.

General consideration of the modus operandi of the proposed new system of paying cane by its analysis: As a technically worked out system it is of easy interpretation and comprehension for technical sugar men. However, bringing the plan to the field of actual practice and subjecting it to the logical reasoning required under the circumstances, it seems that the first obstacle that would hinder its sucessful application is the unpreparedness of the cane planter to see it as easy and advantageous as the technical sugar man sees it. The cane planter must be convinced that he is not going to be burdened with a theoretical system of measurements outside the scope of his human experience. Painstaking accounting must be done. The whole thing is not finished when the chemist states that the cane of Mr. So and So turned out X % sucrose and Y % yield in commercial sugar. The mill management will have to contend with peculiar problems when peculiar circumstances arise; for example, what must be done when grinding immature canes yielding say 7% sugar at the beginning of the grinding season. The Contract must be drawn in such a way as to stipulate clearly whether or not these canes may be refused on the ground that they are immature. Will it be advisable for tahe mill management to fix a minimum yield figure under the system of buying cane by analysis? For the cane planter the acceptance of a fixed minimum percent with which the mill must be guaranteed is tantamount to relinquish any kind of economic protection at the begining of the crop anyway. He would be placed in the same position that the mill owner occupies in the system of paying cane by weight. In order to equitably take care of the small cane planter a carefully worked out system of harvesting, conducted in exact proportion to the available cane supply of each individual, should be enforced. In this manner the small as well as the big cane planter must harvest their cane with such speed and in such volume that the field supply must last through the duration of the crop. If liquidations are made fortnightly, the cane planter will find the liquidations of the beginning of the crop badly disappointing as he will certainly receive less sugar per 100 arrobas cane than in the system of paying cane by weight. The contracts would have to be provided with an approved scale of payment in order to credit the cane planter with the corresponding fractional increase in yield in proportion to the increase in sucrose content in the cane he has delivered. And in the event of cane planters accepting the minimum yield system the approved scale of payment must be adjusted to the following yield limits in cane liquidations: (a) THE MINIMUM FIGURE, (b) CONTRACT FIGURE, (c) NORMAL FIGURE, and (d) MAXIMUM FIGURE, above which the cane planter receives additional compensation to make up any loss he may have sustained at the begining of the crop. A cane planter delivering cane of superior quality would naturally be amply

compensated through the MAXIMUNM FIGURE clause, which answers the stimulus of paying cane by its analysis. It should also be added that the system would very likely be unsatisfactory in districts where several distinct varieties of cane are milled. Any canes materially differing in composition from the Standard Cristalina cane would greatly affect the figures for Mill Extraction and Boiling House Extraction. There would be no possible way of telling the quality and richness of a variety of cane when several varieties are mixed and ground together.

Thus we see that the proposed new system would, at the outset, prove to be somewhat complicated for all of those whose interests it would affect directly, specially the cane planters who constitute a numerous and important social factor to reckon upon. However, there is ample time for devoting due consideration on the adaptability of the system to Cuban conditions, as nothing can be done before existing cane contracts expire.

The advisability of adopting a feasible plan of easier establishment and immediate results would no doubt be the logical step to me taken as a measure of relief in the distressed situation of the mill owner. We have seen plans of gigantic commercial ramifications of world wide distribution in the urgent necessity of market expansion for Cuban raw sugar; we have also seen Governmental intervention limiting domestic sugar production to create demand for the National product; these measures were conceived, advocated, and given due propaganda by distinguished sons of this Country in the noble effort to bring about world wide concerted action in finding a solution to the serious sugar crisis that confromts not only Cuba but also specially the other sugar producing countries of Europe and America. Encouraging results have been awaited for a long time with anxiety. But, since the sugar crisis extends beyond the frontiers of the Cuban Nation, we must realize that quick results are not forthcoming. The mill owners and the cane planters must then give up the hope of relief from without and turn to battle singly with the problem within their mill domains.

A critical examination of sugar mill management reveals that, mechanically speaking, Cuban sugar mills are on a high level of mechanical equipment. Those that have been able to maintain their machinery in good condition of repairs have little to be told. Along cane milling and manufacturing lines there are of course certain suggested changes in order to gauge more accurately the true efficiency of the mill. This, however, means an item of secondary importance in production costs in the well equipped, well organized, and well kept mill. On the other hand, sugar production costs, from the field standpoint, need a careful readjustment of approved and advanced agricultural practice. We have seen that the system of paying cane by its analysis cannot be implanted with the rapidity desired, but we have the system of Field Yield Control by Cane Analysis as a safe alternative.

The end aimed at in both systems is the same; that is, to secure superior and cleaner cane. The system of field yield control by cane analysis has the undisputable advantage of being of feasible and rapid adoption by any mill that desires it without disturbing present management routine. It is then of momentous importance to give it careful consideration.

Numerous instances could be cited where a mill makes heavy investments in its cane plantations in the way of applying commercial fertilizers introducing improved mechanical cultivation, executing drainage projects, striving to obtain cane of superior yields in tonnage and in sugar. Meanwhile, the cane planters grinding their cane supplies at the same mill do nothing, some because they are unable financially

and others because the system of cane payment does not offer any incentive. Their canes will inevitably run inferior in sucrose content and in field tonnage. Their operating returns must be consequently low, which means their running heavier into debt either with the mill or a Banking institution. This is an unsatisfactory state of affairs. The mill is defeated almost at the outset in the purposes that it seeks to accomplish. Let us see how this happens. For an example we will name the cane planters of a cane plantation A, B, C, D, E, F, G, H. Cane planters A and E are enlightened and progressive cane planters and financially able to improve their cane fields. However, they will not spend money and effort in intensifying production, first because they know that they will not receive any reward for any extra effort, and second, because they know that they will receive the same number of arrobas sugar per 100 arrobas cane as cane planters B, C, D, F, G, and H who are unable to do anything. The superior, medium, and inferior canes are finally mixed at the mill yards and ground. The increasing returns that the mill strives to secure are continually being brought down or reduced to a mere average figure by this unbalanced condition of cane culture.

An intelligently applied system of field yield control by cane analysis will ultimately effect the readjustment for a long time needed. A mill possessing a field system wherein the cane fields of each of the cane planters are precisely numbered and conveniently located in blueprint maps, with the help of yield figures actually obtained from the analysis of each carload entering the milling plant, could at once locate the fields and zones producing poor cane. Since the field foremen would be required to keep a record of the more salient field characteristics, such as type of soil, drainage, acreage numbers, mode of cultivation, application of fertilizers, stage of growth of the cane plant, and a complete record of the harvesting operations, then the specific causes could be pointed out without mistake. These specific causes would appear in the form of worn out lands, poorly cultivated fields, improper or no application of fertilizers, left-over cane areas, replating areas, poorly drained areas, diseased cane fields, or plainly immature cane fields in which case a convenient shift should be made without delay. Again, not before these specific causes are known the hit and miss methods of cane culture could be improved. The natural land resources would be properly indexed in a physical manner in a relatively short time. The cane planters and the overseers and managers of mill cane plantations should then be stimulated by encouraging material rewards in the form of a proportionate fractional increase in yield above the figure specified in contracts and salary bonuses when evident superior canes and increased field tonnages are secured. This policy should certainly bear abundant results of great economic value. The system, at the same time, could hardly be condemned or censured as being unscientific. And in case the system should be wanted to be still more scientific, the Arrhenius Map Method of Soil Examination is recommended as being a unique method of soil fertility chemical control applicable to sugar cane soils. This might finally lead into an intensive system of cane culture where the maximum yield in tonnage and in sugar are secured from a minimum of cultivated area.

In the actual execution of the System the field data and the manner of conducting the carload analysis procedure is the same as that already indicated for the system of purchasing cane by its analysis. Since the analytical results would be called upon daily, the procedure of yield estimation on each carload has to be of necessity less astringent so as not to foolishly sacrifice rapidity for accuracy. In order

to facilitate the calculation on the hundreds of carloads of cane ground a convenient Table of Equivalents is submitted. The terms appearing in the Table are:

pJ = Purity of the juice extracted by the first Crusher, from any carload of cane in question.

mJ = Equivalent Purity of the mixed juice.

M = Equivalent Purity of the final molasses.

R = Equivalent Recovery of sucrose % sucrose in juice.

A brief explanation of the meaning of these terms will facilitate the interpretation of the Table. The term pJ is self explanatory. The term mJ originates from the Purity phenomenon that obtains in juice extraction practice. When a comparison is established between the initial Purity extracted (Purity of the juice extracted by the first Crusher) and the total Purity extracted (Purity of the mixed juice) we find what is commonly called the Purity drop. For example, let us take the average figures for the crop of any mill. We find that the Purity of the Crusher juice equals 85.29 and the Purity of the mixed juice equals 82.03; then the Purity drop equals 3.3%. The average Purity drop of the previous year may be used, but if a marked variation is noticed during the progress of the new Crop then the daily Purity drop must be used. Then the average Purity drop, or the daily one, subtracted from any Crusher juice Purity in question will give the equivalent Mixed juice Purity. The term M is derived from the crystallization factor at the Purity of the Juice in question, but slightly modified to adjust it to the Boiling House efficiency of the mill. Knowing the term mJ and M the term R is easily found by the application of the Standard S–J–M formula. For example, in calculating R in the first line of the Table we have:

$$J = 61.0$$
$$M = 23.45$$

The numerical expression would be, $$R = \frac{97\ (61.0 - 23.45)}{61\ (97.0 - 23.45)} \times 100$$

$$= 81.2\ \%$$

The following Table of Equivalents covers practically all possible ranges of Boiling House efficiency and all possible variations in Crusher juice Purities.

TABLE OF EQUIVALENTS

pJ	mJ	M	R	pJ	mJ	M	R
64.5	61.0	23.45	81.2	82.0	78.5	30.25	89.3
65.0	61.5	23.55	81.5	82.5	79.0	30.50	89.6
65.5	62.0	23.65	81.8	83.0	79.5	30.75	89.8
66.0	62.5	23.75	82.1	83.5	80.0	31.00	90.0
66.5	63.0	23.90	82.4	84.0	80.5	31.25	90.2
67.0	63.5	23.95	82.7	84.5	81.0	31.50	90.5
67.5	64.0	24.00	83.0	85.0	81.5	31.75	90.7
68.0	64.5	24.15	83.3	85.5	82.0	32.00	91.0
68.5	65.0	24.25	83.6	86.0	82.5	32.25	91.2
69.0	65.5	24.30	83.9	86.5	83.0	32.50	91.5
69.5	66.0	24.40	84.2	87.0	83.5	32.75	91.7
70.0	66.5	24.50	84.5	87.5	84.0	33.00	92.0
70.5	67.0	24.70	84.7	88.0	84.5	33.25	92.2
71.0	67.5	24.90	84.9	88.5	85.0	33.50	92.6
71.5	68.0	25.10	85.1	89.0	85.5	34.25	92.7
72.0	68.5	25.30	85.3	89.5	86.0	35.00	92.8

pJ	mJ	M	R	pJ	mJ	M	R
72.5	69.0	25.50	85.5	90.0	86.5	35.75	92.9
73.0	69.5	25.75	85.7	90.5	87.0	36.50	93.1
73.5	70.0	26.00	85.9	91.0	87.5	37.25	93.2
74.0	70.5	26.25	86.1	91.5	88.0	38.00	93.4
74.5	71.0	26.50	86.2	92.0	88.5	38.75	93.6
75.0	71.5	26.75	86.4	92.5	89.0	39.50	93.8
75.5	72.0	27.00	86.6	93.0	89.5	40.25	94.1
76.0	72.5	27.25	86.8	93.5	90.0	41.00	94.3
76.5	73.0	27.50	87.0	94.0	90.5	41.75	94.5
77.0	73.5	27.75	87.2	94.5	91.0	42.50	94.9
77.5	74.0	28.00	87.4	95.0	91.5	43.25	95.2
78.0	74.5	28.25	87.6	95.5	92.0	44.00	95.5
78.5	75.0	28.50	87.8	96.0	92.5	44.75	95.8
79.0	75.5	28.75	88.0	96.5	93.0	45.50	96.2
79.5	76.0	29.00	88.2	97.0	93.5	46.25	96.6
80.0	76.5	29.25	88.4	97.5	94.0	47.00	97.0
80.5	77.0	29.50	88.6	98.0	94.5	47.75	97.4
81.0	77.5	29.75	88.8	98.5	95.0	48.50	97.9
81.5	78.0	30.00	89.1	99.0	95.5	49.25	98.2

The expression of the yield formula will be the same as the one already explained under the system of buying cane on basis of its analysis.

That is,

$$X = \frac{s \times J \times E \times R}{P \times 100} \times 100$$

Where,

s = Sucrose in juice expressed by the first Crusher. This let us say belongs to Car No. 447.

J = Java Ratio. Average % during the day. Obtained from Factory Laboratory daily Report.

E = Sucrose Extraction. Average % during the day. Obtained from Factory Laboratory daily Report.

R = Recovery of sucrose % sucrose in juice. Corresponding figure obtained from the Table of Equivalents.

Example: Car No. 447 gave a juice of the following analysis:
19.47 Brix, 16.78 Sucrose, 86.08 Purity.

Java Ratio for the day equals 80.89.

Sucrose Extraction for the day equals 94.40

$$X = \frac{s \times J \times E \times R}{P \times 100} \times 100$$

We look under the column pJ and it is found that 86.08 Purity of the juice extracted by the first Crusher gives a value of 91.2 for the term R. Then,

$$X = \frac{16.76 \times 80.89 \times 94.40 \times 91.2}{96 \times 100} \times 100$$

= 12.16% yield of 96 sugar, which is the yield for the cane in car Number 447. In this manner, within 24 hours after the cane has been ground the yield results on each car are calculated, as shown above, and are henceforth available for information. The statistician in charge will be furnished, at the end of every 24

hours, car analysis data sheet in order to keep field statistics up to date. At the end of the Crop general averages will be calculated for each field and marked on the field Map. The daily yield results on each car analyzed should be consulted by the field Superintendents in order to determine the fields that show evident immaturity and guide harvesting operations accordingly. Once the field statistics are finished mill executives will be in a position to study and locate the dollars that give returns and those that do not. Readjustments in agricultural practice, auditing of production costs on basis of yield returns, and auditing of soil fertility, if necessary, will soon follow. These measures constitute the only tangible help from within to sustain sugar production until the law of supply and demand effects its own natural cycle of readjustment.

TIPOS. - MOLINA Y CIA., RICLA 55-57, HABANA.